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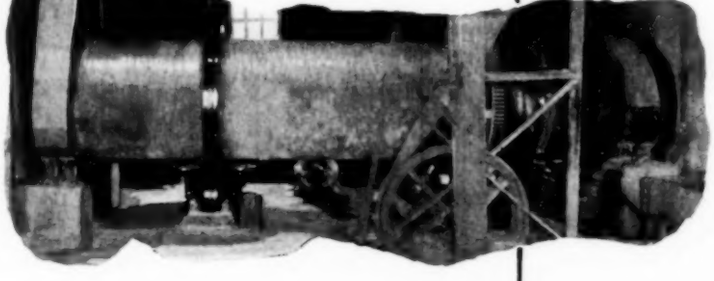

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New Hearings on The Patent Office Bill

WHILE no new arguments against section 9 of the Patent Office bill were offered at the hearings before the joint conference committee of the House and Senate, reported elsewhere in this issue, industrial chemical concerns took advantage of their first opportunity to apprise Congress of their views. They appeared in large numbers, representing the leading manufacturers whose interests are considered jeopardized by the proposal to patent the inventions of Government employees and administer these patents through license by the Federal Trade Commission. In our issue for Oct. 27, 1920, we devoted a great deal of space to the subject, and but little can be added here to the pros and cons there given.

Viewing the matter after this lapse of time and in the light of the representations before the committee at Washington, it is still quite evident that there are some features of the proposal which are rightly objectionable to industry. Even though the measure should fail to function—a probability frankly advanced by unbiased as well as partisan witnesses—its administration involves principles which are repugnant to business men. Will the Federal Trade Commission grant exclusive or non-exclusive licenses? If the latter, none are likely to be taken; if the former, there must inevitably be protest against favoritism. Projecting ourselves into the future operation of the measure, it would seem as though exclusive licenses will be essential to its operation. Non-exclusive licenses will gain nothing more than is now obtained by dedication to the public. Again, what is the proper disposition of useful knowledge gained by Government employees occupied in official duties at public expense? Shall it be parceled out discriminately? And if so, who shall be the fortunate recipient of the product of a public servant's toil? The practical consequence must be confusion, criminations and recriminations.

Further, what is the legitimate field of research for the Government? Should it be in those lines of industry which will yield patentable inventions that will require some special method of administration in the public industry? Shall industry be further encouraged to conduct its own research, using such media as consulting scientists and industrial laboratories, or shall it be discouraged from this course and led to look to the Government for its progress? Admitting that there are now some industries so poorly developed or existing in large numbers of small units, so that they need a correlating agency to assist them, is not the whole idea of industrial research so well developed that in most instances the Government could rely on established private agencies to do the necessary work, and even refer industries to such agencies?

While it is problematical what the joint conference committee will do as a result of the opposition to section 9, we may hazard a guess that it will retain the measure in the bill in spite of the unanimous opposition of industry. The opposition will be discounted on the ground that it represents the selfish interest of large and greedy corporations that wish to stifle Government investigation in the interest of the people. The rôle of the corporations is unpopular, in spite of the fact that they have done and are doing much to advance industrial research which ultimately benefits the consuming public. Nor will the conference committee consent to separate section 9 from the bill for relief of the Patent Office, because thus separated it will have no chance of passage at this session of Congress. Full advantage will be taken of the opportunity of putting the section through as a rider to a measure which has the indorsement of all the people.

When Will Activity In General Business Return?

THE question asked in the caption to these remarks is one that is being heard on all hands, and a wide variety of answers is being given, most of them distinctly evasive. As a rule there is a close connection between the character of answer and the individuality of the one suggesting the answer. The man who has been worrying for a year or two about the high wages the country has been paying answers that activity in business will be restored when wages come down. The man whose hobby is crops and the Western farmers says the farmer owes a great deal of money to the banks and cannot buy until he has paid off his notes, so that it will be a long time before we have business activity. The man who has always considered the railroads the chief source of prosperity in the country holds that activity will return when the railroads begin to buy, but has doubts whether they will do so soon, and so on and so on.

As a test of the prophet's trustworthiness it would be very useful to find out what the man thought six months ago. Probably in nine cases out of ten it would be found that the man who now sets the longest time for the return of activity is the man who six months ago was most strongly convinced that the business conditions of that time were marked for indefinite continuance.

There are men who can be got to admit that in the past few weeks as they have seen prices drop more than they expected and more factories close than they had looked for, they have increased their estimate of the time that will elapse before the wheels of industry are turning freely again. They admit that we are engaged in a process of readjusting. When they see readjustment proceeding rapidly and thereupon lengthen the time estimated for completion of the process they tacitly admit that they had no idea of the extent of the

readjustment requisite, for if the readjustment had a fixed distance to go, the quicker it moved the sooner it would reach the objective.

It seems fairly clear that the readjustment through which we are passing is one of mental attitudes, and such a process does not require a long period of time. Men must become willing to do a bigger day's work and receive only reasonable wages for the day's work. Retailers, wholesalers and manufacturers must become content with moderate profits. An idle workman does not require a long period of idleness for a change of mind. The retailer, particularly if his customers have no jobs, can change his philosophy quite suddenly. There are manufacturers who have closed their plants with the thought that they have accumulated safe reserves and will not resume operations until offered their former profits, but it is not in human nature to enjoy the spectacle of an idle plant for any length of time. The mental reactions can occur in rather a short time. Then there are the buyers, who have gone on strike. They know what they went on strike for—lower prices—but they do not know how much lower. Idleness will become irksome to them also and they will be willing to compromise.

The idea that the readjustment is one of mental attitudes rather than of physical conditions is reinforced by contemplation at long range of mental attitudes during and since the war. Toward the close of the war the majority of people thought that commodity prices would decline immediately after the war, but there were not a few who expected prices to advance very sharply. As a matter of fact, prices did decline after the armistice, and then afterward they advanced a great deal. Evidently there was a very unstable mental condition.

A very common prediction during the war had been that there would be a "transitionary period" while things were getting changed from a war-time to a peace-time basis, and then a prolonged era of great prosperity. We have not had that era of prosperity and there is no proof that we cannot have it. The transition was made difficult by men not taking hold in the right way. First there was fear and then there was inordinate greed, both mental attitudes and both very objectionable. Now we are booked to get into a new mental attitude, and the process does not necessarily require a long period of time.

Beware the Ides of March!

THE present Chief of Staff, General PEYTON C. MARCH, apparently still continues his opposition to proper development of Chemical Warfare Service. In this he is seemingly well supported by the present Secretary of War. However, with the change of Administration we may expect a change in this, as in many other governmental conditions. Indeed, about Washington one hears the very pointed sentence, "March fourth, forth goes MARCH."

One may even believe that it is not committing *lêse majesté* to hope that there will promptly be a selection of a new Chief of Staff who really appreciates and will support (as required by law) the Chemical Warfare Service. The recent report of the special commission headed by General PERSHING to select eligibles for the General Staff affords ample good material for this purpose.

Timeo Danaos Et Dona Ferentes

HAVE you heard of the "Friends of Science, interested in its development"? If not you may yet entertain angels unawares. And if you have not seen the salmon-colored sheet of propaganda for German scientific porcelain, glassware and apparatus, issued by the aforesaid Friends, you have missed an amateurish effort at camouflage that is not very convincing. Anyhow our anonymous Friends are solicitous for the welfare of American colleges and universities, and bemoan the proposed surrender of the privilege which those institutions have enjoyed of importing scientific apparatus and instruments duty free. The Friends would have the privilege retained because it means a continuance of business which German manufacturers have enjoyed for a long time.

The activity of the Friends is timed to a nicety because Congress is now considering emergency tariff legislation, and the Ways and Means Committee of the House is holding hearings on the various schedules of the tariff as a basis for formulating a new law. It is unnecessary for us to go into details of the matter at this time, for we have previously reported and supported the efforts of the chemical and allied industries to protect themselves from ruinous post-war competition and hold the strategic positions gained during the war. It is not Germany alone, but Japan and others, which loom as competitors against which the American industries cannot hold their own in free and unrestricted markets. Wherever these industries bear a vital relation to national welfare, we favor their reasonable protection.

A feature of the Bacharach bill, which passed the House at the last session of Congress and which was favorably reported by the Senate, is a repeal of the duty-free clause of the present tariff law which has long been a concession to our educational institutions. And rightly too, under past conditions. But sympathetic as we are with the financial needs of our schools, we cannot help feeling that they ought to stand on their own feet and pay the bill in order that vital American industries shall live. Most of the consumption by educational institutions is for student purposes, and the cost can be passed on to individuals. Hitherto we have published arguments urging that students should more nearly defray the actual cost of their education, and we support that plea in this instance.

Nor are we unmindful of the excellent arguments on the other side of the question, for of course there are two sides. Elsewhere we publish a communication from Prof. J. W. RICHARDS opposing our own view and supporting the retention of the duty-free privilege. It is but fair to say that Prof. RICHARDS is not alone in his stand, nor do we wish to connect him with the insidious and anonymous propaganda of the "Friends of Science, interested in its development." On the other hand he does not represent all of the colleges, for in the hearings before the Senate it was brought out through a questionnaire that the heads of chemical departments in seventeen out of twenty institutions favored the surrender of the duty-free privilege, even if about one-half of the scientific apparatus and instruments imported come in under the duty-free clause for educational institutions.

There is always room for an honest difference of opinion on questions of policy, and we welcome the frank expression of opinion from those who do not

attempt to conceal their identity. But propaganda is abroad in the land. Naturally it is camouflaged. It poses. It purports to be what it is not. It takes refuge in anonymity, which is the resort of those who have neither the courage of conviction nor pride of opinion. It pretends friendship and unselfish devotion while secretly advancing its own cause. It is rightly an object of suspicion and merits contempt. If the "Friends of Science, interested in its development," had come out into the open, they would at least have been credited with business acumen and integrity.

"I am afraid of the Greeks, even when they come bearing gifts."

Corporation Dividends, Education and Research

ON AUGUST 5 last at the general meeting in England of the corporation of Brunner, Mond & Co. a resolution was passed "that the directors be and they hereby are authorized to distribute to such universities or other scientific institutions in the United Kingdom as they may select for the furtherance of scientific education and research, the sum of £100,000 out of the investment surplus reserve account."

A stockholder named EVANS brought suit to restrain the directors from carying out the resolution, on the ground that Brunner, Mond & Co. as a chemical manufacturer had no business with general science; that the resolution was *ultra vires*, and not within the objects of the company. Mr. Justice EVES in the Chancery Division of the High Court dismissed the complaint. For the purpose of this decision the distinguished magistrate did not discriminate between the powers of the company and its objects, on the ground that its charter permitted it to do all things incidental or conducive to its business as a chemical manufacturer. The evidence showed that it would benefit the community and also the corporation. The objection of the plaintiff that this was too vague was overruled. The directors and others on behalf of the corporation testified that the gift would tend to cause universities and institutions to train students and others whose services would be of benefit to the company. The company acknowledged itself in great difficulty to find the right class of men necessary for the conduct of its business as a chemical manufacturer, and his Lordship concluded that the advantage the corporation would gain by the better provision of properly trained men as a result of the aid thus rendered outweighed the objection raised by the plaintiff that some of the men trained by means of this gift might go to competitors.

A very pretty little scrap, we should say, with an unspoken touch of humor in it. We have plenty of just such persons here, who cannot see what chemistry has to do with selling soda ash. Of course dividends are dividends, and when they are earned and set aside *for the purpose* it would seem that the stockholders have rights in them. We note here a point in bookkeeping—that there may be a hazard in the expression "surplus available for dividends," and that the term "investment surplus reserve account" has greater merit. Research has become a function of industry, research in pure science, at all events, is a legitimate function of university procedure, and that industry needs pure science is shown by the fact that industry needs engineering, and engineering is the application of pure science.

From the record it may occur to some that it contains a hint to the effect that in consideration of the gift, the several universities will train men especially for the alkali industry. We think it more likely, however, that this was allowed to be inferred from the testimony as an argument to win the case than as a statement of conditions. The establishment of Brunner, Mond & Co. is a great and progressive one, and as such its problems are doubtless very like those of great and progressive American organizations. And these are almost unanimous in calling, not for specially trained caustic men or soap boilers or pulp cooks or specialists of any sort, so much as for men whose training in science is broad and general and thorough; it wants men of scholarship in science rather than technicians. Courses in technology are of great value to develop the engineering sense of chemical engineers, but those institutions that give the best courses in this respect would be the last to offer them as a substitute for physics, for instance.

A point that cannot be evansized or made clear to the evans type of mind, or even demonstrated in court, or explained at a stockholders' meeting, is that it is better for a corporation if a competitor makes an advance in applied science than if neither of them makes an advance. In the former case the backward corporation is usually induced to shake a leg, as the saying is, and make an effort to keep up with the procession. The only way to do this is by means of research, even though it takes "surplus available for dividends" to pay for it. In the latter case—that is, if neither the corporation nor its competitor makes an advance—it is bad for the industry as a national institution. For a reason that those who are most to blame are inclined to call "psychological," the industry usually moves away to some other state or country.

Surveys of Chemical Industry

CHEMICAL industry and the Tariff Commission, as well as the Ways and Means Committee of the House of Representatives, are to be congratulated on the completion and publication of technical tariff information with respect to the chemical industry in a way that surpasses all previous effort. This information is presented in the form of reports known as "Tariff Information Surveys," dealing with all phases of tariff policy and tariff legislation now before Congress. They represent an unbiased summary of extended studies by the chemical staff of the Tariff Commission covering a description of each commodity, its uses, methods and processes of manufacture, differences in American and foreign practice, nature and source of raw materials used, data concerning production, import, export, prices and cost of production, and other pertinent facts. In other words, the series is a compendium of industrial chemical information of tremendous value, particularly in tariff revision but also as a general guide to each industry which has been surveyed.

Elsewhere in this issue are given details regarding the nineteen separate pamphlets in which are discussed all of the commodities covered by Schedule A of the tariff of 1913, which schedule relates to chemicals, oils and paints. Whether one is interested in citric acid, wood products, aluminum, chloroform or any other of more than two hundred commodities on which there is duty, or which are specifically mentioned in the "free list," he cannot afford to neglect this important source of reliable and comprehensive information.

Readers' Views and Comments

Duty-Free Apparatus for Colleges

To the Editor of Chemical & Metallurgical Engineering

SIR:—May I ask your indulgence for the presentation of a matter which I realize should appear in the *Journal of Industrial and Engineering Chemistry* but which I am prevented from publishing in that medium through the rather arbitrary action of its editor, Dr. Herty. I refer to a communication which I inserted in the November bulletin of the American Electrochemical Society in favor of duty-free importation of chemicals and laboratory apparatus for colleges and universities, and which was subsequently the subject of an editorial attack on me as secretary of the American Electrochemical Society in the December issue of the *Journal of Industrial and Engineering Chemistry*. When I attempted to reply publicly to the criticism the privilege was denied me on the technical ground that the editor had attacked me as secretary of an organization whereas I responded as an individual. I feel that there are two sides to the question and, with your permission, would like to present the point of view held by some in the colleges.

The Bacharach bill now before the Senate places an increased duty on chemical supplies and apparatus, and incidentally repeals the duty-free importation privilege now possessed by educational institutions. Many college professors, most of them members of the American Chemical Society, believe that such repeal will not only hurt the educational institutions by diminishing the purchasing power of their available funds, but will seriously hamper the efficiency of technical training and thus be detrimental to the progress of the country as a whole.

The argument for the repeal is based principally on the assertion that the enterprises manufacturing these articles are *key industries*, that it is of paramount importance that our country make what it needs in this line, and that in order to assist such industries it is necessary and advisable that the duty-free privilege be withdrawn from educational institutions. It is also stated that the use of foreign supplies and apparatus by our students is detrimental to their patriotism, giving them the idea that the U.S.A. is unable to compete in these things with foreign makers, and thus depressing their ideas of the resources and efficiency of their country.

It can be shown, however, that such repeal is neither advisable nor necessary, and for the following reasons:

1. Educating technical men is also to be classed among the *key industries*, in fact, it is *the master key*. Just as surely as "men are more than kings," just so surely is the efficiency of their technical training of greater importance than the extension of some of our other key industries. If any nation had ulterior designs upon our progress as a nation, which would hurt us most: to hinder our manufactures or to hamper the training and education of our technical men?

2. Duty-free importation was granted by our Government to increase the efficiency of education by increasing the purchasing power of available educational funds. It is certain that withdrawal of this privilege will decrease that purchasing power and therefore reduce the efficiency of the education given.

3. The great increase in industrial control laboratories and private and industrial research laboratories has certainly created a large demand for chemical and physical apparatus and supplies altogether apart from the educational institutions. Since the former cannot import duty free, they may be taxed by duties sufficient to keep our domestic industries going; the same tax on educational institutions would hamper their efficiency simply to make *more* business.

4. Many apparatus and supplies made abroad cannot be obtained in this country at all, being made only abroad. Why make the educational institutions pay a high duty on what is not to be had in this country? If the high duty falls only on the private laboratories, they will certainly look for a domestic source of supply, and thus those who are best able to bear the expense will assist in the establishment of new domestic industries.

5. The proposed repeal hits our allies as well as our former enemies. We get apparatus and supplies from England and France, and it seems unfortunate, to say the least, that we treat friend and foe alike.

6. Concerning the effect on the students' patriotism, I wish to take exactly the opposite stand from that expressed by those favoring repeal of the duty-free privilege. College and university should teach students the truth, and if foreign apparatus and supplies are better or cheaper (duty-free) than the domestic, the students should know it; the last thing to teach them is a blind pseudo-patriotism which thinks that anything American is necessarily the best to be had or is "good enough." Moreover the student who has any red blood in him (and most of them have) will feel a generous ambition to outdo the foreigner when he learns the facts. My experience in teaching university students for over thirty years leads me to state without hesitation that knowledge of the facts stimulates the men by putting a goal of achievement before them, and engenders in them the praiseworthy ambition to try to beat the foreigner.

7. Finally, for purely pedagogic and efficiency reasons, teaching equipment should be the very best obtainable, irrespective of its source. If I wish to show a student of qualitative analysis the reaction of potassium, it is of first importance that I use the purest potassium salt I can get (and am able to buy) irrespective of its source. If I want to show my students the spectra of the elements, I should have the best spectroscope my funds will procure, irrespective of who makes it, in order to raise my teaching to its highest efficiency.

When it comes to education and training of our technical men, we can very well afford to use foreign materials from any source when by so doing we can thereby increase the efficiency of the education given, and thereby eventually acquire the ability to beat the foreigner at his own business. Any other principle will result in hampering technical education, and thereby defeating the very ends that we wish to accomplish. I plead for a broader vision and for a further look ahead:

J. W. RICHARDS.

Department of Metallurgy,
Lehigh University,
Bethlehem, Pa.

Hearings on Patent Office Bill

Conference Committee Reopens Hearings on Bill for Relief of the Patent Office in Order to Give Opponents of Section 9 Opportunity to Register Their Objections

AS ANNOUNCED in our issue for Dec. 29, 1920, the joint conference committee of the House and Senate on the Patent Office bill reopened hearings on that measure and listened to a large number of witnesses on Jan. 5 and 6. In convening the session Senator Norris, presiding, called attention to the extraordinary nature of the proceedings—holding hearings on a measure which had passed both houses of Congress and which had been referred to conferees for adjustment of differences. He explained that the committee could listen to arguments bearing on only those matters on which the House and Senate were in disagreement. These were particularly the matter of salaries and clerical force in the Patent Office, and section 9, relating to the patenting by the Government of the inventions of its employees and assignment of such patents to the Federal Trade Commission for administration through license.

Salary Reductions Inserted by Senate

H. R. 11984, as passed by the House for the relief of the Patent Office by increasing the salaries of employees and increasing their number, was amended by the Senate reducing the salary recommendations of the House and reducing the force of employees. As brought out in the testimony, the effect of the bill would be to reduce the force 15 per cent at a time when the work of the office has increased 30 per cent. It was also shown without difficulty that salaries in this important bureau of the Government were woefully inadequate, being very much lower than those paid in private industry for similar service, as well as being incommensurate with the education and technical ability required of Patent Office employees. Testimony was introduced by former Patent Commissioner Ewing to show that the Patent Office had been steadily disintegrating for the past thirty years, due to failure to provide salaries that would hold competent men. He explained that the patent system of the United States requires examiners who are not only skilled in patent law but whose familiarity with conditions in the Patent Office is essential to the expedition of business. Deterioration of the force, through loss of examiners by resignation, not only retards prompt attention to applications but makes it impossible to give to applicants the careful consideration necessary to avoid the issuance of invalid patents. Mr. Ewing stated emphatically that unless prompt relief were granted the Patent Office would be congested with a volume of work that could not be transacted, and industry would suffer.

Necessity for Increasing Salaries Urged

Among others who testified regarding the inadequacy of the present salaries, or even those contemplated by the Senate amendments, was E. J. Prindle, who stated that resignations in the Patent Office were continuing in spite of the fact that the present bill promised some relief. He cited these resignations as evidence that the prospect of receiving the lower salaries recommended by the Senate was not sufficiently attractive to hold men in their positions, and he urged the restoration of the salaries recommended by the House. Mr. Prindle offered resolutions passed by the National Research Council, Engineering Council, American Chemical Society and National Association of Manufacturers supporting the necessity for relief in the Patent Office. He also introduced some results of a questionnaire of the American Patent Law Association, showing that former examiners in the Patent Office are now receiving from private industry salaries several times as great as they received in the Government service. Practically all of the witnesses before the committee, including those who appeared for other reasons, indorsed heartily the necessity for increasing salaries in the Patent Office and providing a force adequate to cope with the business of that bureau.

House Provision Likely to Be Reinstated

In explanation of the Senate's amendment reducing salaries it should be stated that the Senate is not unalterably committed to that program, nor does it necessarily believe that the House provisions were too high. It was felt that the subject of salaries should receive the attention of the Senate conferees, and the best way to do that was to introduce amendments. Senator Norris stated in the hearings that the two committees were not in material disagreement on this point, from which it may be inferred that the contentions of the witnesses will prevail and that the House provisions will be reinstated after they have been reviewed.

Opposition to Section 9

Opponents of section 9, which the Senate attached as a rider to H. R. 11984, appeared before the committee in large number, representing chemical manufacturers and industrial companies. The arguments were mainly a repetition of those published in CHEMICAL & METALLURGICAL ENGINEERING of Oct. 27, 1920, following a meeting of several scientific societies in New York before which Dr. Cottrell and Dr. Alsberg spoke in behalf of the measure. Practically all of the witnesses opposing this section of the bill not only objected to it in principle but felt that it should not be attached to the bill for relief in the Patent Office. They advocated its elimination and separate consideration.

The gist of the opposition to section 9, as expressed before the committee, is that it will bring the Government into competition with private industry; that the Federal Trade Commission as the administrative agency has not the confidence of the country; that the granting of licenses involves the question of discrimination among competitors in an industry; that the Federal Trade Commission would be under the necessity of defending title to its patents for the benefit of its licensees; that dedication of a patent to the public meets satisfactorily the condition which section 9 proposes to relieve; that if Government research is con-

ducted in the proper sphere of fundamental science or in those industries for which there is no established research agency no need will exist for section 9; that if Government research is not so conducted it will extend into development work that will involve large expenditures; that more extensive industrial research by the Government will discourage private industry from extending its research activities and rely more and more on the Government for the solution of its problems; and that no special machinery is required to meet the situation as stated by proponents of the measure.

Administration Under Proposed System Questioned

The possibility of administering satisfactorily patents assigned to the Federal Trade Commission was the subject of much of the testimony and of colloquies between members of the committee and witnesses. It was contended by the latter that the licensing of patents would be the cause of much dissatisfaction to the inventor and the industry and the public. Frederick P. Fish stated emphatically that the Federal Trade Commission would find itself confronted with the necessity of choosing between exclusive and non-exclusive licenses; that if the former were adopted there would be dissatisfaction among unsuccessful applicants and the Commission would find itself open to the charge of favoritism. When Senator Norris said that he doubted if much hue and cry would be raised by the granting of an exclusive license Senator Brandegee retorted, "Let the Commission grant an exclusive license to the Standard Oil Co. and see what will be said." In Mr. Fish's opinion this feature would open the way for a vast amount of dissatisfaction if not scandal. If the Commission should grant non-exclusive licenses it would seem unlikely that any would be taken, in which event nothing more would be accomplished by the bill than by original dedication to the public.

Limitation of Government Activity Urged

On the contention that dedication to the public is now satisfactorily meeting the situation R. P. Perry, of The Barrett Co., introduced some evidence based on the premise that "industry, inventors and the large majority of the American public believes that governmental activities should be limited to those fields where private industry cannot function as well and that private enterprise should be encouraged in all fields where it can function as well as or better than the Government."

Continuing, Mr. Perry said: "Now what does this mean in the present case? It means simply this, that the proper and legitimate sphere for Government technical research is, in the opinion of industry, limited to such work as formulating standards of quality in fields of general public interest (drugs, foods, etc.), developing testing methods and determining accurate fundamental data, such as the true physical constants of materials and making investigations in fields of agriculture and animal industry not reached by private enterprise. It means that Government technical research is out of bounds when it goes into the development of new products or processes in chemical or other applied industry. The legitimate need to be met is therefore, in my opinion, a limited need and if the Government keeps within its proper sphere it will only very occasionally and incidentally develop any patentable inventions relating to applied industry and consequently will very seldom have occasion to take out patents. I cannot conceive of it other than as a very limited need unless Government technical research unconsciously or consciously is to invade the fields of private enterprise in competition with industry. . . . I believe such invasion will sooner or later be the inevitable result of the plan proposed by section 9. At the present moment the point is that unless there is to be such expansion of effort into the field of private industry the needs to be met are limited and the present arrangement has met these needs."

By way of proof that under present conditions Government inventions are exploited by the public when open to public use Mr. Perry cited the instances of calcium arsenate, which was developed by the Bureau of Chemistry as an insecticide; oil- and water-proofing in concrete, developed in the Office of Public Roads; hog cholera serum, a product of the Bureau of Chemistry; and phthalic anhydride, developed in the Color Laboratory.

Another Objection to Section 9

An objection raised by Mr. Perry and others to the present innovation embodied in section 9 is that it will be an entering wedge that will not stop with the patenting of inventions made by Government employees in the course of their official duties, but that since an undeveloped invention is worth little or nothing there will be a great temptation to develop patents so that they will be of some value to the inventor and the Federal Trade Commission. Indeed, it was the contention of witnesses that undeveloped patents would find little or no sale, and that development would be essential if the plan of section 9 were to amount to anything and meet the expectations of its sponsors.

The prospective expense to the taxpayers entailed by this experiment in patent administration was the subject of attack by witnesses. Mr. Randall, secretary of the Air Reduction Co., foresaw the necessity for the Federal Trade Commission building up within itself an organization for the expert administration of patents, defending infringement suits, etc. Senator Norris asked why it would be necessary for the Federal Trade Commission to defend patent suits. He was informed that prospective licensees would not accept a license, especially if non-exclusive, if there was a prospect that they would have to prosecute infringers or stand suit for infringement in case their patent should prove invalid. The situation would be little better in the case of exclusive licenses, and in any event it would be incumbent on the Federal Trade Commission to maintain an elaborate legal department.

An interesting witness was former Commissioner of Patents Ewing. Speaking from some years of experience he expressed opinions on various points brought out by other witnesses. In his judgment it would be necessary to issue exclusive licenses if the scheme were to have any chance of success, and yet he felt that there was so much objection to that kind of discrimination that it would kill what little chance of success there might be for section 9 to function as its sponsors hope. In Mr. Ewing's opinion the whole matter would not amount to anything, because it would not work practically. He was certain that the Government would have to protect its licensees by defending patent suits.

A. I. C. E. Opposes Section 9

David Wesson presented the attitude of the American Institute of Chemical Engineers as follows:

The Institute has an able committee on patent legis-

lation which reports at the regular semi-annual meetings progress of all patent legislation.

The Nolan bill, as originally passed in the House, was discussed by the Institute in open meeting and approved.

When section 9 was added to the bill the Institute, in conjunction with the New York sections of the American Chemical Society, the Electrochemical Society and the Society of Chemical Industry, held a special meeting in October last in New York at which Dr. Cottrell and Dr. Alsberg fully explained the intent and meaning of section 9.

The meeting, representative of the industrial, scientific thought of the country, discussed the proposition, which was disapproved by all who spoke on the subject.

The patent committee of the Institute reported the bill at the annual meeting held in New Orleans Dec. 6, 1920. The following resolution was drawn up and unanimously adopted:

> *Be It Hereby Resolved*, That Congress be petitioned to pass Bill H.R. 11,984, otherwise known as the Nolan bill, in its original form, without the addition of section 9, that the Patent Office may obtain the needed relief to maintain its efficiency; and be it further
>
> *Resolved*, That we consider the passage of section 9 would lead to the interference by the Government bureaus with business enterprises with which they were originally designed to co-operate in supplying service and benefit to all.

Rust Memorandum on Section 9

Mr. Randall asked the committee to divorce section 9 from the bill in anticipation of the substitution therefor of an act to be drawn by co-operative effort of all the parties at interest. He summarized the hearing with the following wire from H. B. Rust, president of the Koppers Co.:

The principal purpose of our patent system is to encourage private enterprise and invention. This section will do exactly the opposite.

1. It will place a body of Government-owned and administered patents, worked out by Government inventors at public expense, in competition with another body of patents developed and owned by private industry. Such an effect is bound to be discouraging and harmful to all industry.

2. It will make it possible for executive orders to direct that all patents taken out in any Government bureau be turned over to the Federal Trade Commission for administration.

3. It will make the Federal Trade Commission a holding agency for a great group of patents affecting practically every branch of private industry.

4. It will make it possible for the Federal Trade Commission to discriminate in the issuance of licenses, allowing them to certain parties and refusing them to others.

5. It will even make it necessary for the Federal Trade Commission to so discriminate, "for unless licenses are restricted in number there is no gain over dedication of the patent to the public in the first instance."[1]

6. It will make it possible for a taxpayer of the United States to be refused the right to use an invention that he has contributed funds to develop.

7. It will involve private industry in continual litigation with the Government on questions of patent validity, infringement, etc., litigation that will become a burden ont only to the parties, but to the public.

8. It will discourage the co-operation between Government bureaus and private concerns that is now benefiting both. Private industry will certainly not be willing to give Government employees information that may later be developed into patents and turned against it.

9. It will place any Government bureau developing patents in an unfair position with respect to related industries in competition. The Government bureau has means, not possessed by any private individual, of acquiring information from competitiors. Such information can and will be used in the development of patents and to the detriment of competing industries.

10. It will give undue personal benefit to the Government employee working with the advantage of Government funds and Government information.

11. It will give undue personal benefit to a favored group of Government employees who happen to be so placed that they can work on inventions, as compared with the many other employees who are not so placed.

12. It will place an irresistible temptation before Government employees, especially of the technical and scientific groups, to devote their time to work on patentable inventions that will lead to personal benefit to themselves.

13. It will create dissatisfaction among those employees who are not permitted to work on inventions.

14. It will seriously curtail the fundamental technical and scientific activities of various Government agencies that have few patentable possibilities, but are, nevertheless, of the utmost value to industry.

15. Under the patent law of the United States, inventions, made by an employee at his employer's expense, belong to the employer. The employer of every Government employee is the public. Inventions of Government employees are made at the expense of the public and should belong to the public without any qualification such as this section 9 introduces.

The conference committee of the House and Senate is respectfully urged to reject this section.

Dr. Cottrell Speaks for the Section

Dr. Frederick G. Cottrell, late Director of the Bureau of Mines and new chairman of the Division of Chemistry and Chemical Technology of the National Research Council, appeared in behalf of section 9. Dr. Cottrell is generally recognized as principal sponsor of the bill. He explained to the committee that this is an experiment in administration of patents in the interest of the public; that in the course of official duties Government employees produce as a byproduct certain patentable discoveries which, unless patented and administered, will be lost to public use; that dedication to the public does not, in his opinion, meet the situation; and that the bill has been drafted as a permissive measure to try the experiment of assignment to a public body and administration by it. In the course of his testimony Dr. Cottrell was questioned by a representative of the Standard Oil Co., who asked, in effect, "Would the industrial concerns with which the various Government bureaus now have co-operative agreements allow Government employees to enter their works and laboratories if they suspected that later they might be asked to pay a royalty on some invention made as a result of knowledge and information picked up in the course of co-operative relations?" Dr. Cottrell was of the opinion that the operation of section 9 would not affect the cordial relations now existing between Government bureaus and various industrial concerns. He spoke from some years of experience in administration of Government technical work, and said that in his judgment there was great need of some such medium as section 9 in order to salvage and make available for public use many discoveries now lost. At the present time there are a number of such patented discoveries awaiting the establishment of a suitable agency through which the patents can be assigned and licensed. In reply to the criticism that the Federal Trade Commission would experience a great deal of difficulty in licensing patents Dr. Cottrell cited the fact that during the war that body administered a number of enemy-owned patents, licensing their use without difficulty.

[1] Quotation from Chem. & Met., Oct. 27, 1920.

Bacteria as Chemical Reagents

Activities of Micro-Organisms—Factors Determining the Extent of Chemical Transformations by Bacteria—Food for Bacteria and Its Influence on Their Activities—Bacterial Standards of Purity—Chemical Equation of Life

BY ARTHUR I. KENDALL

AT THE very foot of the ladder of life, the simplest in structure and the smallest in size, there is a group of micro-organisms known as bacteria. The sinister impressions which arise at the mere mention of germs, indeed all the notoriety which attaches to the term "bacteria," arise from the malignant potency of a small but formidable group of these micro-organisms—the pathogenic microbes—whose activities are in opposition or partial opposition to those of plants, animals or man.

In reality the prime function of bacteria in nature is one of beneficence. Without their participation in the rotation of certain elements between the living and the dead all life would inevitably cease upon this planet. Bacteria maintain a balance between the organized and unorganized kingdoms in nature. They restore those essential elements, of which the available supply is limited, to the soil in fully oxidized form, suitable for resynthesis by plants through the agency of sunlight acting upon chlorophyll. Otherwise much nitrogen and other elements essential to the perpetuation of life would be locked up in complex, useless combinations in the dead bodies of plants and animals and their waste products, while vestiges of the slowly weathering corpses of prehistoric monsters and prehistoric vegetation would still encumber the earth.

ACTIVITIES OF MICRO-ORGANISMS

The purification of water and sewage by bacterial action is illustrative of their analytical activation. The soluble organic substances of sewage and contaminated water are broken into simpler hydrolytic products through the action of soluble digestive enzymes which the bacteria secrete, and in turn these relatively simple compounds are absorbed, digested and excreted by microbes as fully oxidized derivatives of nitrogen, carbon, etc. Such compounds are available for plant synthesis. The biological purification of water and sewage, therefore, is essentially a process of bacterial digestion. The rapidity with which the biological purification of water and sewage takes place in specially constructed filters is illustrative of the advantage of creating favorable conditions which thus hasten the natural process. It also indicates the great measure of chemical transformation which these very small microbes bring about.

In addition to the great analytical processes of the nitrogen cycle, which are caused by bacteria, the artificial and natural souring of milk, of ensilage and many other preservative processes are the work of microbes. The fermentation industries for the production of organic acids, alcohols and many patented reactions, and a multitude of others, all indicate uses to which the intelligently controlled activities of micro-organisms can be applied.

Micro-organisms play an important part in the human economy. The ravages of tuberculosis, typhoid, cholera, dysentery, diphtheria and other infections are well known, but the normal bacteria of the alimentary canal also exercise a protective function against invasion by them. The extent to which this protection shields the host against contagion is not yet known, but unquestioned evidence exists in favor of it. Modern research is leading to the formation of dietary measures which will increase this protection, or re-establish it, if it has been diminished or lost.

Bacteria are minute, unicellular organisms, devoid of sex, and their reproduction is a simple and rapid process. They are also devoid of any catalytic pigment, as chlorophyll, so that it would appear to be impossible for bacteria to become synthetic agents, as are the green plants. Bacteria require preformed food in their dietary; hence their activities are essentially analytical rather than synthetic. The perpetuation of bacteria requires an expenditure of energy, and the source of this energy, as will be shown, is of leading importance.

FACTORS DETERMINING THE EXTENT OF CHEMICAL TRANSFORMATIONS BY BACTERIA

The simplicity of structure of bacteria and absence of any photochemical agent, such as chlorophyll, within them automatically reduce their activities to two closely related but very distinct processes. These are, first, an anabolic, or structural, process or phase, and, secondly, a vegetative energy, or katabolic phase. The former perpetuates the integrity of the species, the latter determines the function of the organism.

Now it is just because the individual bacteria are so small that their activities are so great. The physical basis for this resides in the large ratio of surface of the organism to its volume or weight, and also to the rapidity with which successive generations of bacteria appear when conditions are favorable to their growth.

The cholera vibrio, for example, measures about 2 microns in length and 1 micron in diameter. The volume, therefore, of a single cholera germ is about 0.000000002 cu.mm., while its surface measures nearly 0.00001 sq.mm. For purposes of comparison it may be stated that a man weighing 100 kg., 200 cm. in height, has a surface area of approximately 2.4 sq.m.

Since the energy requirement of living things varies with the surface area rather than the volume or weight, it is evident that the relatively large surface area of bacteria in proportion to their volume or weight creates a condition requiring proportionately a great deal of energy to maintain them. It should be borne in mind, however, that the energy requirement of bacteria, measured in terms of chemical transformation, depends somewhat on the type. Thus, bacteria which play a prominent part in natural processes appear to effect chemical transformations of even greater magnitude than those of

similar size which are pathogenic for man. The second factor which plays an important part in determining the extent of chemical transformation by bacteria is the amazing rate of reproduction. Under favorable conditions successive generations of cholera vibrios may appear at intervals as frequent as every fifteen minutes, each individual dividing into two individuals in this short time. The theoretical descendants of a single vibrio, therefore, in four hours would number about 32,000. The weight of the progeny would be approximately 0.00064 mg., while the combined surface of the descendants of a single organism at this time would be nearly 0.32 sq.mm. The energy requirement of a four-hour culture, therefore, would have increased 32,000 times, but the actual amount of material necessary to build up the bodies of the microbes at this time would be only 0.00066 mg. in weight. Fortunately such a rate of reproduction cannot long be maintained. Nature provides barriers and restraints, and these always keep proliferation within endurable limits. Were this not so man and animals would long ago have perished.

Essential Food for Bacteria

Bacteria, in common with all known living entities, contain nitrogen as an essential element in their structure. Now nitrogen is notoriously an inert element, and this inertia is perhaps a feature of stability in the changing manifestations of protoplasm. Nitrogen is therefore necessary for the structure of all bacteria, and reproduction and growth are impossible in environments which do not contain it in utilizable form.

The nature of the nutritional compounds containing nitrogen required by bacteria is varied. Some types appear to use simple combinations of nitrogen with hydrogen, carbon and oxygen. The great majority of micro-organisms can derive their nitrogen requirement from amino acids or relatively simple polypeptids. Some —as the fastidious *gonococcus*—require practically unaltered protein from human sources for their cultivation.

Nitrogen, although essential for the structural requirements of bacteria, is without apparent value as a source of energy. This is true for animals and man as well. Indeed, when appropriate nitrogenous compounds, as protein or protein derivatives, are the sole source of dietary energy for bacteria, animals or man the carbon of the protein or its derivative is oxidized for this purpose only after the nitrogen is removed from the molecule by a process of deamination. The ammonia resulting therefrom is left unchanged, or transformed to urea and excreted in this form.

Dietary energy for bacteria and for animals arises from the intracellular oxidization of carbon, so far as we can judge from available evidence. It is also generally true that the partly oxidized carbon existing in carbohydrates is more readily utilized than the reduced carbon of the amino acids, for the same purpose.

The waste products arising from the utilization for energy of such nitrogenous substances as amino acids, polypeptids or proteins, furthermore, are, as we have indicated above, strikingly different from those derived from the intracellular combustion of carbohydrates. A few examples will illustrate the immense importance of this difference.

Influence of the Culture Medium on the Activity of the Bacteria

One of the leading culture mediums for bacterial cultivation is called "plain" or sugar-free broth. It consists essentially of a sterile aqueous solution of 1 per cent of peptone and 0.3 per cent meat extracts, all neutral in reaction. This medium offers amino acids and polypeptids as the sole sources of nitrogen, carbon and other elements essential for bacterial growth. In such a medium, therefore, both the structural and energy requirements of bacteria must be obtained from amino acids, or combinations of amino acids, which are not coagulated by heat.

An entirely similar medium, both in composition and reaction, but containing about 1 per cent of glucose, is designated "glucose broth." Both plain and glucose broth offer to bacteria amino acid complexes for structure. But in plain broth these same amino acids are also the sole sources of carbon for the energy requirement of the bacteria, whereas in glucose broth a choice is available between the nitrogen-containing carbon complexes—i.e., amino acids and their derivatives—and the non-nitrogenous carbohydrates for the energy requirements of the microbes.

The diphtheria bacillus is an organism whose formidableness to man is measured by the potency of the water-soluble, extracellular toxin it produces. Under certain conditions 0.025 c.c. of a seven-day *plain* broth culture of this organism will kill a guinea pig weighing 250 g. within four days with definite symptoms and lesions.

In other words, in the plain broth, in which carbohydrates are lacking, the energy requirement as well as the structural requirement of the diphtheria bacillus is derived from the utilization of protein derivatives, and under this condition a very powerful specific soluble poison is produced which is the deadly weapon of the diphtheria bacillus. The same diphtheria bacillus, however, grown in the same medium but to which a small amount of glucose is added, produces substances which are not even slightly poisonous; they are, in fact, potentially buttermilk. Instead of producing the virulent poison they secrete essentially lactic and acetic acids.

The diphtheria bacillus, therefore, under the conditions of culture stated above, is a veritable Dr. Jekyll and Mr. Hyde. Grown in a purely protein medium it produces a virulent poison; in a glucose-protein medium it forms potentially buttermilk. The utilization of glucose in place of the nitrogenous amino acid complexes for energy is the only known factor concerned in this remarkable transformation.

The colon bacillus, a common inhabitant of the intestinal tracts of man and of animals, produces considerable amounts of indol from the utilization of tryptophan, an important amino acid, when protein derivatives are the only available sources of energy. When a utilizable sugar—as glucose—is added to the medium the products arising from the growth of the organism fail to include indol. They are, on the contrary, principally lactic and acetic acids. [It would appear from this that glucose might occasionally be used advantageously to avoid the evil odors attendant on putrefaction.—Ed.]

The bacteria which incite typhoid fever, bacillary dysentery, cholera and many other diseases react in a precisely similar manner; they produce characteristic nitrogenous products, which appear to be specific for each organism, all nitrogen-containing, when protein or protein derivatives only are available for energy. All of these formidable incitants of human infection, however, produce the chemical equivalent of buttermilk when an available source of energy in the form of carbohydrate is present in mediums where they are growing. Generally speaking, the carbohydrate spares the protein constitu-

ents of the nutritive environment from decomposition for the energy requirements of the organism.

Importance of the Utilization of Protein and Carbohydrate for Energy

It is obvious, therefore, that in either medium protein must be used for the structural requirement of the organisms, and it is also evident that the products arising either from the utilization of protein or from that of carbohydrate for *energy* should be of great significance in defining the function of the various kinds of bacteria. This is emphasized by the far greater requirement of bacteria for energy than for structure.

This great fundamental principle of the use by bacteria of either carbohydrate or protein for energy is in all probability the most important single principle to note in approaching the unexplored field of the chemistry of medical, agricultural and industrial bacteriology.

An illustration or two will be explanatory.

Many years ago at the Lawrence Experiment Station at Lawrence, Mass., bacterial sewage filters which had nitrified the organic constituents of sewage successfully for a period of years were found to permit the passage of the nitrogenous constituents of sewage but little changed in terms of free and albuminoid ammonia when cane sugar was added to the sewage just before it was introduced to the top of the filter. An explanation was not available when this experiment, repeated several times, was performed. In all probability this is a concrete example of the sparing action of carbohydrates for proteins in fermentation. If it is easier for the bacteria resident in the filter to obtain their energy from cane sugar than from the nitrogenous constituents of the sewage they will do this very thing, and the effluent will show theoretically but little chemical evidence of nitrification.

Several years ago certain eggs, broken and mixed with a considerable amount of cane sugar, were seized and condemned on the ground that they were filthy, rotten and decomposed. There were many thousands of colon bacilli per gram of egg, and it is known that *Bacillus coli* produces relatively large amounts of indol, an exceedingly foul-smelling substance, from the decomposition of protein.

Most careful analysis confirmed the high bacterial content of these eggs, but failed to reveal ammonia, indol or other products indicative or even suggestive of protein decomposition by *Bacillus coli*. The reaction of the eggs, contrary to what might have been expected from protein putrefaction, was distinctly acid, and lactic acid in considerable amounts was found in the mixture. These eggs, furthermore, were used in cakes and other culinary products without the slightest suggestion of disagreeable odor or taste. What appears to have happened is readily explained—the colon bacilli derived their energy requirement from the cane sugar, leaving the protein of the egg practically untouched except for the minimal amounts necessary to fulfill their nitrogen structural requirement. Evidence of protein decomposition would scarcely be expected under the circumstances, and in reality the principal change was at the expense of the cane sugar, rather than the protein.

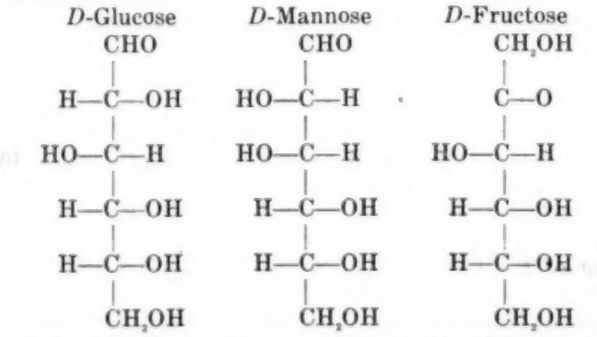
Nature's method of preserving milk by souring, so extensively practiced in the tropical and subtropical Orient, especially by nomadic peoples, and the recently developed use of bacteria for "starters" in the butter industry are examples of the selective action of bacteria upon sugars in place of the protein constituents. The development of acid tends to retard, or even prevent, the growth of non-lactose-fermenting proteolytic bacteria which otherwise might induce putrefaction in place of souring. Examples might be cited almost without limit upon this phase of the problem, but another phase deserves mention because of the theoretical possibilities associated with it.

Significance of "Utilizable Carbohydrate"

For many years, beginning with 1885, bacteriologists have added various sugars, starches and glucosides to plain broth, and have observed that specific bacteria differ in their respective powers to "ferment" or "not ferment" the various carbohydrates. Long-continued observation has led to the selection of a few sugars for general bacterial use, the kinds depending somewhat upon the organisms studied. Thus glucose, lactose, saccharose and the alcohol mannitol have been found by repeated trials to be of great use in separating bacteria derived from the alimentary canal into distinct types or species. Confirmatory tests, using the serums of horses immunized to certain of the respective pathogenic types, have been employed in the final diagnosis of these.

Although the empirical facts relating to the respective availability of such carbohydrates have been thus laboriously established, the underlying principle appears to have been overlooked. This principle is that in the presence of such utilizable carbohydrates they are consumed by the bacteria for their energy requirement, while the protein constituents of the medium are spared. The recognition of the principle of this *sparing action* of utilizable carbohydrate leads at once to a contemplation of the most fundamental consideration of all—what relationship exists between the structure of a utilizable carbohydrate and the ability of the living protoplasm of a specific organism to use such a structure as a source of energy? Some of the relationships between the stereo configuration of very closely related sugars and their respective values as sources of bacterial energy are truly amazing in their specificity. Bacteria are extraordinarily delicate appraisers of optical antipodes; that is, they are themselves sentitive polariscopes.

D-glucose, *d*-mannose and *d*-fructose differ, according to available information, solely in the arrangement of hydrogen and hydroxyl around the carbon atom next to the aldehyde group—except in fructose, which is, of course, a ketone. The brilliant researches of Emil Fischer and others have shown the specific arrangement of the six carbon, twelve hydrogen and six oxygen atoms which collectively determines the identity of each member of this group, which tends to form a dynamic chemical equilibrium of the three through a common *enol* when any one of them is dissolved in an alkaline aqueous solution.



Furthermore it will be seen from the diagram that

d-glucose and *d*-mannose differ from each other solely in the arrangement of the H and OH groups next to the aldehyde group. This difference consists merely of a reversal of the two in mannose as compared with glucose. Neither the number nor the kind of groups of atoms differs; it is merely a transposition of one H and one OH upon one carbon atom out of the six. The remaining carbon atoms and associated groups are precisely the same. Yet certain bacteria, as *Bacillus proteus*, and cholera vibrios can derive energy from the intracellular utilization of glucose, but appear unable to utilize mannose in the slightest degree. On the contrary, bacteria which are apparently much more fastidious in many of their dietary requirements, especially with reference to protein, can ferment mannose as well as glucose. Observations with several hundred bacteria, comprising many of the more important pathogenic types, have revealed similar instances of a most extraordinary relationship between the structural configuration of various carbohydrates and their susceptibility or immunity to specific bacterial decomposition. Apparently definite strains of bacteria never make a mistake in picking out the proper structural formula for transformation into energy. Thus two strains of cholera and proteus, tested at intervals of four years, have consistently used glucose and refused mannose, as stated above. Whether all strains of cholera or of proteus, for example, that are in existence at the present time would be unable to utilize mannose cannot be decided in the light of available information. Conversely, if strains said to be one or the other of these types are found which ferment mannose, an extremely fundamental question of their respective identities would at once be raised.

Observations upon one hundred different strains of dysentery bacilli have revealed one small group of three which do not ferment galactose. They do ferment (as do all the remaining types which could utilize galactose) glucose, mannose and fructose, as well as other sugars.

So far as available evidence goes, the alcohol *d*-arabitol is fermented only by members of the *Mucosus capsulatus* group. If a large series of authentic strains of this group exhibit in common this peculiarity, a means of rapid diagnosis for one group will have been demonstrated. The application of this principle along the line of specific bacterial diagnosis is perfectly obvious.

Bacterial Standards of Purity

The unerring, uncanny positiveness with which the two cholera and two proteus organisms distinguish between glucose and mannose suggests at once a means of detection of traces of the former sugar as an impurity in the latter. The extension of this principle to possible bacterial standards of purity for all sugars and indeed for many other substances through a careful selection of particular bacterial strains for specific purposes needs no further elucidation.

As an example of the possible delicacy of such a reaction mention may be made of the common use by bacteriologists of milk containing litmus as an indicator. Milk as ordinarily purchased and used in bacteriology contains about 3 per cent of protein, 3 per cent of fat, and 5 or more per cent of carbohydrate in addition to inorganic salts and water. Clearly, bacteria have a theoretical choice of protein or carbohydrate for energy. Fats are omitted for the sake of simplicity from this discussion. The carbohydrate content of milk consists of somewhat less than 0.1 per cent of glucose, the remainder being lactose.

Dysentery bacilli and many others can ferment glucose but not lactose. Bearing in mind what has been said, it is obvious that the theory outlined demands a primary bacterial attack upon the glucose for energy. If this is used up without the formation of products inimical to the further growth of the bacteria they must subsequently derive their energy from the protein constituents of the milk, because experience has shown that dysentery bacilli cannot attack the lactose.

The products of the fermentation of glucose by dysentery bacilli are acid; those arising from the putrefaction of the milk proteins are alkaline. The litmus indicator shows this sequence very clearly. It responds to the acidity generated from less than 0.1 per cent of glucose by turning distinctly violet, then it gradually becomes blue as the alkaline products of protein decomposition for energy accumulate and neutralize the fermentation acid.

This is a crude illustration of the ability of specific bacteria to distinguish very small amounts of a specific carbohydrate in the presence of another. Even with the relatively gross conditions of this experiment the results are unmistakable. How delicate such a reaction can be made is yet undetermined. The application of this principle to the identification of minute amounts of specific sugars and to the products of hydrolysis of bioses and polysaccharides is perfectly clear.

Attempts to produce bacterial evidence of enolization and subsequent equilibrium of hexoses (as of the glucose-fructose-mannose group) in alkaline media have so far been unsuccessful, although the prevailing idea regarding this phenomenon should be susceptible of demonstration.

Chemical Equation of Life

However interesting, instructive or important the relationships between structure of carbohydrates and their adaptability for energy may be as abstract phenomena, there is underlying all these manifestations the problem of the chemical equation of life. The remarkable precision with which bacteria of certain types distinguish between such closely related hexoses as glucose and mannose has its exact counterpart in the equally astonishing phenomena of specific immunity and susceptibility of animals and man to bacterial infection.

Man is relatively free from many of the epizoötic diseases of animals, and animals do not naturally become infected with many human infections, as typhoid fever. Much more specific examples of immunity and susceptibility to infection are known, however. Algerian sheep are said to be immune to anthrax, that bacterial pestilence which has decimated herds of ordinary sheep both in Europe and America. House mice are extremely resistant to infection with glanders, while field mice are unusually suspectible. Goats are not readily infected with tubercle bacilli, but cattle and swine are extremely prone to the disease.

Science is wholly uninformed with respect to the origin and mode of the action of immune processes. Much empirical knowledge has been laboriously collected concerning the methods of testing such immunological phenomena, but an adequate, satisfying explanation of them is wholly and entirely lacking.

At first sight the enormous complexity of proteins to which immunological processes are ordinarily ascribed

would appear to be an insurmountable barrier to further advances. Seventeen amino acids which comprise the building blocks of the proteins may be arranged in hundreds of thousands of combinations within a molecule as large as that of a native protein. Realizing what a mere transposition of H and OH in glucose does in creating bacterial immunity, the enormous complexity of the extension of this process to protein and protoplasmic sources is very obvious.

Nevertheless, bacteria may throw some light even here. *Bacillus coli* and *Bacillus proteus* and some others are tryptophanophilic; in the absence of non-nitrogenous sources of energy they appear to pick out tryptophan from the protein molecules and utilize the alanin portion, leaving indol as a useless residuum. Other bacteria select other amino acids. Without prolonging this suggestion and without mentioning some other features of bacteria decomposition of protein which are pertinent, it may be stated that untouched possibilities remain which the bacteriological chemist of the future will study and from which he will glean information leading directly to the heart of that mystery of mysteries, the chemical equation of life.

Use of Bituminous Coal as Water-Gas Generator Fuel*

By W. W. Odell†

IT HAS long been recognized that coke is a more desirable fuel than bituminous coal in water-gas apparatus of present design, but still considerable headway has been made in the use of the latter fuel as a substitute for coke. This is particularly true in the Central States, where the supply of high-grade coke has been very limited and uncertain during the past few years and where coking coals of low sulphur content were available in quantities. In fact, with the present difference in price of coal and coke, it is possible to realize a marked saving when using a coking bituminous coal as generator fuel.

Difficulties have been encountered in the use of such fuel, but they have been overcome to a large extent. One of the chief obstacles in the use of the more general utilization of bituminous coal for water-gas manufacture is the fact that with normal operation the capacity per unit of time is reduced. This of course is a serious problem for plants operating at capacity with coke fuel. However, this difficulty can be remedied to a large extent by a changed method of operating, and can be remedied entirely by a combination of the latter with a change in the design (or proportions) of a water-gas set. The preceding statement, it will be understood, refers more particularly to a carburetted water-gas set.

Present Practice in the Manufacture of Water Gas From Coke

In the manufacture of water gas from coke present practice requires that for continuous 24-hr. service the heat of combustion of all the carbon monoxide (CO) generated during the air blow be utilized in addition to the sensible heat of the gas coming from the generator.

This is doubly true when making carburetted water gas from bituminous coking coal. The reasons why this is so are apparent when the following factors are considered.

The average value of the blue gas from coke fuel is 300 B.t.u. per cu.ft., whereas that from the coal is 335 B.t.u. Also the volume and quality of the blast gas are appreciably greater when the latter fuel is used. In other words, when making carburetted gas from bituminous coal the quality of the blue gas is so much richer than the same gas from coke that less oil is required to carburet it to a given standard. Therefore less heat is required for heating the checker chambers. This condition is aggravated by the fact that more and richer blast gas is available than ever, and must be wasted at the stack in large quantities when making gas to a standard lower than 565 B.t.u. The lower this standard the greater the quantity of blast gas wasted. Therefore, with the present tendency toward lower standards for city gas, the benefits to be realized by the utilization of a waste heat boiler are at once apparent.

The general practice in the past in the use of waste heat boilers has been to utilize only the sensible heat of the gas, no consideration being given to the heat of combustion of the excess combustible blast gas. This is perhaps due to the fact that when making carburetted gas to a 600 B.t.u. standard or better, using coke fuel, there is but little combustible gas wasted, since more oil is used per 1,000 cu.ft. of gas and the percentage of blue gas in the finished gas is lower. The changes brought about by the use of bituminous coal as generator fuel and by the lower gas standard materially alter this condition and make it particularly desirable to supply a combustion chamber in conjunction with a waste heat boiler for utilizing the heat of combustion of the waste blast gas.

Advantages of Using Bituminous Coal as Water-Gas Generator Fuel

In drawing attention to the use of bituminous coal as generator fuel it is not my purpose to claim that it is better fuel than coke but to point out that:

1. Carburetted gas can be made from it cheaper than with coke, due to the fact that although slightly more generator fuel is used per 1,000 cu.ft. of gas produced, the difference in the prices of coal and coke is great enough to offset this difference. Also, the oil consumption per 1,000 cu.ft. is less, due to the higher heating value of the blue gas from coal fuel.

2. A still greater economy can be realized from the use of such fuel (bituminous coking coal) when a properly designed waste heat boiler with a suitable combustion chamber is provided.

The Bureau of Mines in its investigations of the use of central bituminous coals as water-gas generator fuel, conducted at its mining experiment station at Urbana, Ill., has made a special study of the design of types of water-gas sets using coal. A report on the results of the study of this problem, entitled "Water-Gas Apparatus Designed for Use With Bituminous Coal as Generator Fuel," by William W. Odell, has just been completed, and will appear as a Bureau of Mines publication. Another paper to be published by the bureau of interest to those concerned in the manufacture of carburetted water gas is a report of experiments made during July and August, 1920, in the use of mixed fuels, coal and coke, on a commercial scale, making over 1,000,000 cu.ft. of gas a day.

*From Reports of Investigations, U. S., Bureau of Mines.
†Gas engineer, Bureau of Mines.

Density of Aluminum From 20 to 1,000 Deg. C.

Experimental Methods for Measuring With Precision the Density of Liquid Metals, and Figures for the Results When Applied to Pure Aluminum — Derived Data of Importance Are Solid Shrinkage, or Pattern Allowance, and Solidification Shrinkage

By JUNIUS DAVID EDWARDS* and T. A. MOORMANN†

ONE of the most interesting properties of aluminum from the standpoint of usefulness is its low density, and innumerable determinations of its density have been made. This work has nearly all been confined, however, to the observation of the density at "room" temperatures. In the technology of aluminum, the density of the liquid metal is a significant factor and there are no accurate data on the density of liquid aluminum in the literature. Furthermore, there has not always been a satisfactory correlation of the density of the material with its chemical composition and physical structure. It has been necessary, therefore, in some of our work to determine certain of these constants of aluminum and its alloys. This work has not only made available an exact knowledge of the density under varying conditions but has led to some very interesting observations and conclusions regarding the process of solidification of aluminum and its alloys. These results are of particular interest in connection with the casting of aluminum alloys. This paper is one of a series which will describe the work and the conclusions reached.

The term density, as used in these articles, may be defined as the mass of the metal in grams per milliliter. The density multiplied by the factor 0.0361 gives the mass in pounds per cubic inch. These values refer to weighings *in vacuo;* weighings made in air with brass weights and an equal arm balance will be about 0.03 per cent less. The specific volume is the reciprocal of the density or the volume in milliliters per gram of mass.

Experimental Methods

The density of metal at room temperature has been determined in the usual manner by determining the apparent loss in weight when immersed in water. A platinum wire 0.10 mm. in diameter was used for supporting the specimen. No correction has been made for the effect of surface tension on the wire, because in nearly every case the correction is much less than one part per thousand. All weighings are corrected to *in vacuo.*

The determination of the density of the liquid metal presented greater difficulties. An attempt was made to determine the density by determining the apparent loss in weight of a sinker immersed in the metal. Fused quartz appeared to be the material best adapted for the construction of the sinker because of its low coefficient of expansion and it was hoped that it would not be seriously attacked by the aluminum. Because the density of fused quartz is insufficient to insure its sinking in liquid aluminum, a hollow quartz sinker was constructed with a cylinder of nickel or iron inside to increase its weight. A short, slender, quartz rod 1 mm. in diameter was attached to the top of the sinker, and this was suspended by a platinum wire. The sinker is illustrated in Fig. 1. A number of results were obtained with this design of sinker, and they are in fair agreement with the results obtained by the densimeter method to be described later. The quartz sinkers are, however, quite rapidly attacked by the metal, particularly at temperatures above 700 or 800 deg. C., and the behavior of the sinker becomes erratic and the results unreliable. This method was accordingly abandoned in favor of another method. However, such a sinker would give very satisfactory results in contact with a metal or liquid which did not attack it and they can be readily constructed with a little practice.

Densimeter of Frary and Edwards. It has been found possible to determine the density of liquid metals with good precision by means of a densimeter devised by Dr. F. C. Frary and one of the authors. Fig. 2 shows a graphite densimeter of this type which was used with liquid aluminum and its alloys. The small inner crucible is completely filled with metal at a temperature somewhat below that at which its density is to be determined, and the cover is screwed down tight by means of two steel screws. The space between the inner and outer crucibles is filled with aluminum until the surface of the metal is about 0.5 in. from the top of the inner crucible; this bath of metal aids greatly in securing a uniform and constant temperature in the inner crucible.

The temperature of the furnace is then slowly increased until the bath of metal shows the desired temperature as measured by a platinum-platinum rhodium thermocouple, and then is carefully held at this temperature for from five to ten minutes. Great care is exercised to reach this temperature slowly, and not to exceed it at any time. As the temperature rises, the aluminum in the inner crucible expands and completely fills the crucible. The excess runs out through a very small channel formed by a groove in the top face of the crucible and the tightly fitting cover. Any beads of metal adhering to these openings are detached, the crucible is removed from the furnace, the metal in the surrounding bath is poured out, and the crucible is allowed to cool. When cold, the ingot is removed and weighed. The volume of the inner crucible has previously been determined by weighing the volume of mercury just required to fill it. The volume of the crucible at the temperature of measurement is calculated by means of the expansion coefficient of Acheson graphite, as determined by Day and Sosman.[1] This correction is

FIG. 1. SINKER

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[1]Day and Sosman, *J. Ind. Eng. Chem.*, vol. 4, p. 490 (1912).

small—only 0.65 per cent at 1,000 deg. C. The density is readily calculated from the weight of the metal and the volume it occupied at the temperature of the determination. This method was considerably more precise than the sinker method but required a longer time to carry out a series of determinations.

Density of Solid Aluminum

The density of a metal is subject to variation from changes in both composition and structure. As a result, the data on the density of aluminum as well as the density of other metals are frequently both conflicting and confusing. When metals are cast there are certain voids left in the metal as cracks, pores, etc. The application of pressure to the metal as in rolling or cold working tends to eliminate these voids, with a resultant increase in density. It has been observed, however, by a number of investigators that continued working of many metals eventually results in a decrease of density, and that annealing of these hard-worked specimens results in an increase of density. The explanation of this interesting phenomenon as proposed by Beilby[2] lies in his "amorphous phase" theory. According to this theory the deformation of the metal results in the transformation of small amounts of the crystalline metal into an amorphous modification possessing properties similar to those of a super-cooled liquid. This amorphous metal should have theoretically a lower density than the crystalline modification, and so its production lowers the average density of the metal. Upon annealing, the amorphous metal crystallizes and the density increases. These changes are not large in magnitude, but are apparently well authenticated. A good review of the evidence has been given by Johnston and Adams.[3] More recently Hull[4] has shown that mechanical working tends to change the crystal structure of aluminum from a face centered cubic lattice to a hexagonal arrangement. The changes in density under discussion might possibly be accounted for by some such change in crystal structure without recourse to the amorphous phase theory. In the case of aluminum, Kahlbaum[5] found the density of a sample of hard-drawn aluminum wire to increase from 2.6995 to 2.7031 upon annealing. Brislee[6] in an extensive series of experiments found variations of the same magnitude between hard-drawn and annealed aluminum wire, and somewhat smaller differences in the case of metal which had not suffered as great deformation.

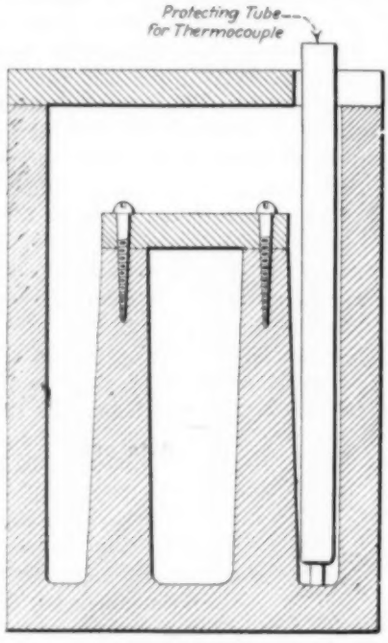

FIG. 2. DENSIMETER OF FRARY AND EDWARDS FOR LIQUID METALS

A number of tests were made by the authors to confirm these observations; a summary of these tests is given in Table I.

The sample of very pure metal (99.75 per cent) taken from the pig was increased in density from 2.686 to 2.703 by rolling; annealing produced no further change, however. Two samples of hard-rolled sheet (99.23 per cent) decreased slightly in density upon annealing. A cast sample of low-grade metal decreased in density with compression, and later increased upon annealing. According to the theory, the increase of density upon annealing should be greatest in the specimens which had suffered the greatest deformation. To test this point, samples of conductor wire were twisted almost to the breaking point. In the two tests made, there was an increase in density upon annealing, and the increase was greatest in the case of the wire most severely deformed. The decrease in density caused by annealing of the hard-rolled sheet referred to may have been caused by expansion of pores and fissures during annealing with its consequent crystal growth. The last-mentioned specimens had not received severe mechanical treatment.

It may be of interest to calculate the percentage of metal which must be present in the amorphous form to account for the observed changes in density. Take, for example, the sample of No. 10 wire which increased in density from 2.703 to 2.706 upon annealing. If it is assumed that the density curve of the solid amorphous metal is continuous with that of the liquid, then by extrapolation of the graph of Fig. 3, the density of amorphous aluminum at 20 deg. C. would be approximately 2.55. A simple calculation from the corresponding specific volumes shows that the presence of 1.8 per cent of amorphous metal of the assumed density would account for the change in density from 2.703 to 2.706.

TABLE I. EFFECT OF PHYSICAL TREATMENT UPON DENSITY OF ALUMINUM

Purity of Sample, (per Cent Al)	Condition and Treatment of Sample	Density, (20 Deg. C.)
99.75	Sample sawed from pig	2.6827
	Sample sawed from pig	2.6861
	Same, cold rolled from ¼ to ⅛ in.	2.7031
	Preceding sample, annealed 15 min. at 850° F.	2.7030
	Same, annealed 2 hr. longer	2.7030
99.23	Hot rolled to ¼ in.; finished to 0.22 in.; not annealed	2.7078
	Same, after annealing	2.7069
	Hot rolled to ¼ in.; finished to 0.27 in.	2.7077
	Same after annealing	2.7057
98.25	Small ingot cast in graphite	2.7279
	Same, compressed under load of 50,000 lb.	2.7258
	Same, after annealing at 850° F.	2.7266
99.49	Wire from aluminum cable	2.7064
	Another sample of same after twisting severely	2.7046
	Preceding sample annealed	2.7055
	Another sample after twisting very severely	2.7052
	Same, after annealing	2.7091
99.5	Hard drawn aluminum wire, No. 10 gage	2.7029
	Same, after annealing	2.7063
	Hard drawn aluminum wire, No. 6 gage	2.7019
	Same, after annealing	2.7048

Although we have contributed very little to the evidence on this phase of the investigation, the following conclusions seem warranted:

The working of cast aluminum increases its density by the elimination of voids. A point may be reached, however, at which further deformation of the metal results in a decrease in density, and the annealing of such metal again produces an increase in density. This

[2]Beilby, *J. Inst. Metals*, vol. 6, p. 5 (1911).
[3]Johnston and Adams, *J. Am. Chem. Soc.*, vol. 34, p. 563 (1912).
[4]Hull, *Proc. Am. Inst. Elec. Eng.*, vol. 38, p. 1,171 (1919).
[5]Kahlbaum and Sturm, *Z. anorg. Chem.*, vol. 46, p. 217 (1905).
[6]Brislee, *Trans. Faraday Soc.*, vol. 9, p. 162 (1913).

latter effect is best explained by the production of amorphous metal during working, which modification has a lower density than crystalline aluminum.

Examination of the available data indicates, in the authors' opinion, that the density of pure annealed

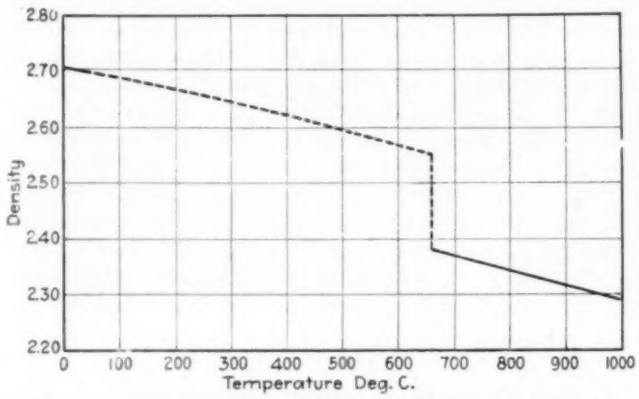

FIG. 3. DENSITY OF ALUMINUM, 99.75 PER CENT Al (DOTTED PORTION OF GRAPH WAS CALCULATED)

aluminum (100 per cent aluminum) is very close to 2.700. Samples of hard drawn wire of high purity may have densities only slightly lower than this value (for example, 2.699 or 2.698), caused by the mechanical working. Much lower values than these indicate the presence of voids. Small increases in the amounts of the usual impurities present cause an increase in density as indicated in Table IV.

Thermal Expansivity of Aluminum

A knowledge of the thermal expansivity of aluminum can be used to calculate the density of aluminum at higher and lower temperatures than "room" temperature. A summary of the available measurements is given in Table II.

TABLE II. THERMAL EXPANSIVITY OF ALUMINUM

Observer	Thermal Expansivity $\Delta l/l_0$	Temperature Range, Deg. C.	Purity of Metal Tested
Bureau of Standards[7]	$(22.31t + 0.011152) 10^{-6}$	15 to 295	Si = 0.45% Fe = 0.35%
Dittenberger[8]	$(22.536t + 0.017071t^2) 10^{-6}$	0 to 610	"Pure"
Jaeger and Scheel[9]	$(22.9t + 0.009t^2) 10^{-6}$	−78 to 500	Al = 99.6%

These results show some little variation, and we are adopting for the present the value obtained by the Bureau of Standards. The Bureau of Standards is also determining the expansivity of a sample of 99.75 per cent purity, but the results are not yet available.

[7]Bureau of Standards, Circular 76 (1919).
[8]Dittenberger, *Z. Ver. deutsch. Ing.*, vol. 46, p. 1,532 (1902).
[9]Jaeger and Scheel, *Elektrotech. Zeit.*, p. 150 (1919).

The density of the metal might be determined directly at the higher temperatures by the method of hydrostatic weighing if a suitable medium could be found. Oil might be used up to 300 deg. C., but beyond that temperature we have been unable to find any mixture of fused salts which would remain sufficiently constant in density to give satisfactory results.

Density of Liquid Aluminum

Using the densimeter method outlined in a previous section, the density of aluminum has been determined from the melting point to slightly above 1,000 deg. C. The expansion is apparently linear over this range. The results of these tests are given in Table III. In a later section will be found a table of densities more convenient for use, and which have been taken from the "smoothed curve" fitted to the following data. For the sake of comparison the deviation of each point from the smoothed curve is given in the table. This curve is based entirely on the measurements with the densimeter; the observations taken with the sinker are obviously of somewhat lower precision.

TABLE IV. DENSITY OF ALUMINUM

Temp.	Condition of Metal	Density: 99.75 per Cent Aluminum	Density: 99.4 per Cent Aluminum	Density: 98.25 per Cent Aluminum
Centigrade Temperature Scale				
20	Solid	2.703	2.706	2.727
100	Solid	(2.69)	.....	.....
200	Solid	(2.67)	.....	.....
400	Solid	(2.62)	.....	.....
658.7	Solid	(2.55)	.....	.....
658.7	Liquid	2.382	2.384	2.405
700	Liquid	2.371	2.373	2.394
800	Liquid	2.343	2.345	2.366
900	Liquid	2.316	2.318	2.339
1,000	Liquid	2.289	2.291	2.311
1,100	Liquid	2.262	2.264	2.285
Fahrenheit Temperature Scale				
68	Solid	2.703	2.706	2.727
1,217.7	Solid	(2.55)	.....	.....
1,217.7	Liquid	2.382	2.384	2.405
1,300	Liquid	2.369	2.371	2.393
1,400	Liquid	2.354	2.356	2.377
1,500	Liquid	2.339	2.341	2.362
1,600	Liquid	2.324	2.326	2.347
1,700	Liquid	2.309	2.311	2.332
1,800	Liquid	2.294	2.296	2.316
1,900	Liquid	2.278	2.280	2.301
2,000	Liquid	2.263	2.265	2.286

NOTE.—Values inclosed in parentheses are calculated from expansion formula.

The density of the liquid (99.75 per cent aluminum) may be expressed by the following equation, in which D_t is the density at the specified temperature of t deg. C.

$$D_t = 2.382 - 0.000272(t - 658 \text{ deg.})$$

The only other data available on the density of liquid aluminum are those of Pascal and Jouniaux[10] and Richards.[11] The sinker method was used by Pascal and

[10]Pascal and Jouniaux, *Rev. Metallurgie*, vol. 11, p. 1,069 (1914).
[11]Richards, *J. Frank. Inst.*, vol. 138, p. 51 (1894).

TABLE III. RESULTS OF DENSITY DETERMINATIONS OF LIQUID ALUMINUM

Sample No.	Composition of Metal: Si per Cent	Fe per Cent	Cu per Cent	Mn per Cent	Al per Cent	Density Method	Temperature, Deg. C.	Density, g./ml.	Deviation From Best Curve, per Cent
7	0.25	0.26	0.08	None	99.38	Sinker No. 1	665	2.391	+ 0.38
7	0.25	0.26	0.08	None	99.38	Sinker No. 1	718	2.376	+ 0.34
7	0.25	0.26	0.08	None	99.38	Sinker No. 1	754	2.364	+ 0.25
7	0.25	0.26	0.08	None	99.38	Sinker No. 2	959	2.280	− 0.96
7	0.25	0.26	0.08	None	99.38	Sinker No. 2	1,012	2.256	− 1.40
12a	0.19	0.24	0.07	None	99.50	Densimeter	952	2.304	0.00
12c	0.17	0.23	0.07	None	99.53	Densimeter	701	2.372	0.00
A1	0.11	0.13	0.008	None	99.752	Densimeter	708	2.368	0.00
A1	0.11	0.13	0.008	None	99.752	Densimeter	897	2.317	0.00
A1	0.11	0.13	0.008	None	99.752	Densimeter	995	2.287	− 0.13
A1	0.11	0.13	0.008	None	99.752	Densimeter	996	2.282	− 0.35
72	0.38	0.53	0.32	0.52	98.25	Densimeter	706	2.391	− 0.04
72	0.38	0.53	0.32	0.52	98.25	Densimeter	822	2.362	+ 0.08
72	0.38	0.53	0.32	0.52	98.25	Densimeter	912	2.335	− 0.04

NOTE.—Four determinations have been omitted from the table, as having been obtained with a defective crucible; the results of these determinations were so far off as to be obviously incorrect.

Jouniaux with a quartz crystal as the sinker. They report values about 3 per cent higher than ours on metal for which they claim a purity of 99.48 per cent. The density of this metal is given as 2.794 at 20 deg. C., so there is obviously something wrong either with their technique or their analytical results, because metal of the stated purity could not possiby have a density as high as 2.79. Richards determined the weight of aluminum filling an iron mold of known volume and estimated the density of "molten aluminum" (temperature not specified) to be 2.54, which value is also high.

Tables and Curves of Density, 20 to 1,000 Deg. C.

In Table IV are shown the values for the density of several grades of metal at various convenient temperatures. The values for the solid metal at high temperatures were calculated by means of the expansion formula referred to in the preceding section. The values of liquid density were taken from graphs plotted from the data of Table III. In Fig. 3 the density of "A" (99.75 per cent aluminum) is shown graphically.

Shrinkage of Aluminum

From the preceding data several interesting conclusions may be drawn regarding the shrinkage of aluminum in casting. The "solid shrinkage" of the pattern maker is the linear contraction in cooling from solid metal at 658 deg. C. to room temperature. As calculated from the expansion formula this amounts to 0.22 in. per ft. Tests made on bars cast between two graphite blocks, rigidly held a known distance apart, gave the value 0.21 in. per ft., which is in quite fair agreement with the calculated value.

The foundryman is also interested in what may be called the "solidification shrinkage" and the "liquid shrinkage." The solidification shrinkage may be defined as the percentage change in the volume of the metal in cooling from a liquid at the freezing point to a solid at the melting point of the metal. In the case of a pure metal, the freezing point and the melting point are identical. It is this shrinkage which is responsible for the pipe which is formed when the metal is cast. The liquid shrinkage is the contraction of the liquid in cooling to the freezing point and of course varies with the temperature interval through which the metal cools.

TABLE V. SHRINKAGE OF ALUMINUM

Temperature Deg. C.	Temperature Deg. F.	Total of Solidification and Liquid Shrinkage From *t* Deg. C. to Solid at 658 Deg. C.—Percentage of Original Volume	Remarks
658	1,216	6.6	Calculated from data of Table IV.
700	1,292	7.2	Calculated from data of Table IV.
800	1,472	8.2	Calculated from data of Table IV.
		7.7	Shrinkage measured on ingot cast at 1,550 deg. F.; temp. estimated at 100 deg. C. lower at completion of filling of crucible.

Referring to Fig. 3, the solidification shrinkage in metal changing from liquid of density 2.382 at 658.7 deg. C. to solid of density 2.55 at the same temperature is 6.6 per cent. Toepler[12] reports the solidification shrinkage of aluminum to be 5.1 per cent. In the casting of aluminum it must, of course, be poured at a higher temperature than 658 deg. and the total of the solidification shrinkage and the liquid shrinkage will be correspondingly greater. In Table V are given the values for this total shrinkage from various temperatures as calculated from the graph of Fig. 3. There is also included an actual measurement of the shrinkage in a small experimental ingot. The method used was to cast an ingot in a small graphite crucible of known volume (about 240 c.c.) and then to measure accurately the volume of the pipe by weighing the volume of contained mercury. The volume of the pipe, corrected for solid shrinkage, was then expressed as a percentage of the original volume of the metal. The pouring temperature of the ingot was 1,550 deg. F. (843 deg. C.), and it will be noted that if we make the reasonable assumption that the average temperature of the metal was about 100 deg. C. lower at the time the filling and leveling of the crucible of metal was completed, then the calculated shrinkage is in good agreement with the observed value.

[12]Toepler, *Wied. Ann.*, vol. 53, p. 343 (1894).

Summary

The density of pure, annealed aluminum (100 per cent aluminum) is estimated to be very close to 2.700. The effect upon the density of small changes in composition and changes in structure produced by mechanical working, etc., are discussed in this paper. A graphite densimeter has been developed for determining the density of liquid metals and a series of determinations carried out on liquid aluminum of various grades. The density of liquid aluminum (99.75 per cent aluminum) may be obtained from the following equation:

$$D_t = 2.382 - [0.000272(t - 658 \text{ deg.})]$$

The solidification shrinkage or volume change of aluminum on freezing is shown to be close to 6.6 per cent.

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Rubber in the Manufacture of Dynamite

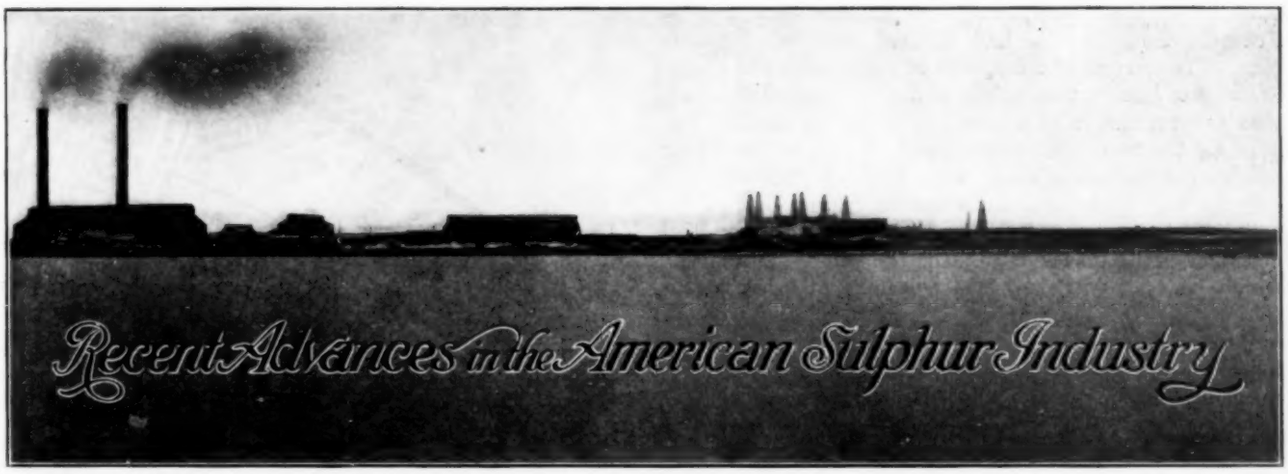
An interesting note on the important part played by rubber in the manufacture of nitroglycerine and dynamite will be found in *India Rubber World*, Nov. 1, 1920, p. 114.

During the nitration of the glycerine and the subsequent settling, neutralization and washing, the workmen are protected from acid burns and toxic absorptions by rubber gloves and boots. The pure nitroglycerine is conveyed to the storehouses in rubber-lined gutters.

From the storehouse the nitroglycerine is taken to the mixing house in a copper-lined, rubber-tired buggy provided with long rubber tubes for discharging the contents. The absorbents, such as sodium nitrate, ammonium nitrate or wood pulp, are added in the mixing machine, a large wooden bowl in which large hard-rubber-tired wooden wheels revolve. The loose dynamite is removed by wooden shovels to wooden tubs, thence to the packing machine, where it is packed into paraffined paper shells by means of wooden tamps tipped with rubber.

A New Sweet

The *Bulletin* of the Imperial Institute (vol. 18, pp. 123-5, 1920) reports that a sweet of remarkable potency is found in a plant called "caa-che" (*Stevia rebaudiana*), that flourishes in Paraguay. The sweet constituent is a glucoside called estevia, which is accompanied in the plant by another sweet constituent, rebaudin, probably a compound of estevia with sodium or potassium. Estevia and rebaudin are said to be respectively 150 and 180 times as sweet as cane sugar.



Present Status of Industry, With Special Reference to Recent Operations in Texas—Pyrites Versus Sulphur as a Source of SO_2—Effect of Traces of Petroleum—Properties and Uses—Sulphur as an Engineering Material

By RAYMOND F. BACON* and HAROLD S. DAVIS†

SULPHUR plays a more basic rôle in chemical industry than any other element. Either as elementary sulphur or combined as a metallic sulphide, it is the source of all sulphuric acid. Hence any changes in the sulphur industry should be of great interest to the chemical engineering profession.

America now dominates the sulphur industry and virtually all the American sulphur is produced by three companies—viz., the Union Sulphur Co., the Freeport Sulphur Co. and the Texas Gulf Sulphur Co. These three companies produce not only virtually all the sulphur used in the United States but also a considerable surplus which is exported. The only other sulphur which normally enters the American market in quantity comes from Japan[1] and its percentage calculated on the consumption of the United States is small and is not likely to increase. Rising costs of living have meant much higher wages in Japan, as well as in other parts of the world; in fact, the percentage increase has probably been greatest in Japan, due not only to world conditions affecting all countries but to the rising standards of living of the Japanese. These facts, together with present higher transportation costs, will make it increasingly difficult for Japanese sulphur to compete on our Pacific Coast with the American product.

Expansion of Industry During War

During the World War, and especially after America's entry into it, the demand for sulphur grew enormously. Some time previous to our declaration of war consideration had been given by a certain group of New York capitalists to the opening up of the sulphur deposit (known as the "Big Dome") located near Matagorda, Tex. These plans were hastened to realization by our Government's need and demand during the war for the maximum production from every possible source of sulphur. The plans eventuated in the formation of the Texas Gulf Sulphur Co., which, however, did not get its plants into operation until after the armistice. Production has been practically continuous since the company first mined sulphur on March 19, 1919. The plant of this company, which has been described elsewhere,[2] was designed to have a capacity of 1,000 tons of sulphur per day, but for months at a time during the past year it has produced on an average 2,000 tons per day. The total production for the year 1920 exceeds 800,000 long tons, while in all probability the production for 1921 will be the largest of any sulphur company in the world. The possible daily production with the present plant, under favorable conditions, could be forced to three or four thousand tons per day. The deposit contains upward of ten million tons of sulphur; and a brief description of its character is as follows:

Description of Big Dome at Matagorda

The main deposit has a diameter of about 4,000 ft. and is situated 800 to 1,000 ft. below the surface of the ground. The sulphur occurs in an almost flat stratum, whose general shape is like that of a flat-topped umbrella. Above the sulphur stratum is an unconsolidated sediment consisting of bands of shale, gumbo and boulders. Below is a layer of salt and gypsum, and then a layer of salt of undetermined but very considerable thickness. The sulphur content of the deposit runs quite uniform with a slightly higher percentage of sulphur on one side of the dome. The mining operations are carefully checked, and a large-sized model of the deposit enables the engineers constantly to visualize what is taking place underground.

Production and Stocks Exceed Post-War Normal Demand

At the time the Texas Gulf Sulphur Co. entered the market the situation was about as follows: The Union Sulphur Co. had on top of the ground, in unsold

Read before the American Institute of Chemical Engineers, New Orleans, Dec. 6, 1920.

*Director of the Mellon Institute of Industrial Research of the University of Pittsburgh.

†Industrial Fellow of the Mellon Institute of Industrial Research of the University of Pittsburgh.

[1] However, no Japanese sulphur is being imported into this country at the present time.

[2] Chem. & Met. Eng., vol. 20, No. 4, pp. 186-188. *Eng. Min. J.*, vol. 107 (1919), pp. 555-7.

stock of sulphur, upward of one million tons and the Freeport Sulphur Co. had several hundred thousand tons. The normal consumption of sulphur in the United States had been between four and five hundred thousand tons per annum, which quantity could be readily supplied by the two older companies.[3] A new sulphur company entering the market with a large production of sulphur was therefore compelled to pursue one of two policies—either to attempt to obtain a share of the business by cutting prices or to place the sulphur in markets which had not hitherto used sulphur; in other words, to increase the sulphur consumption of the country.

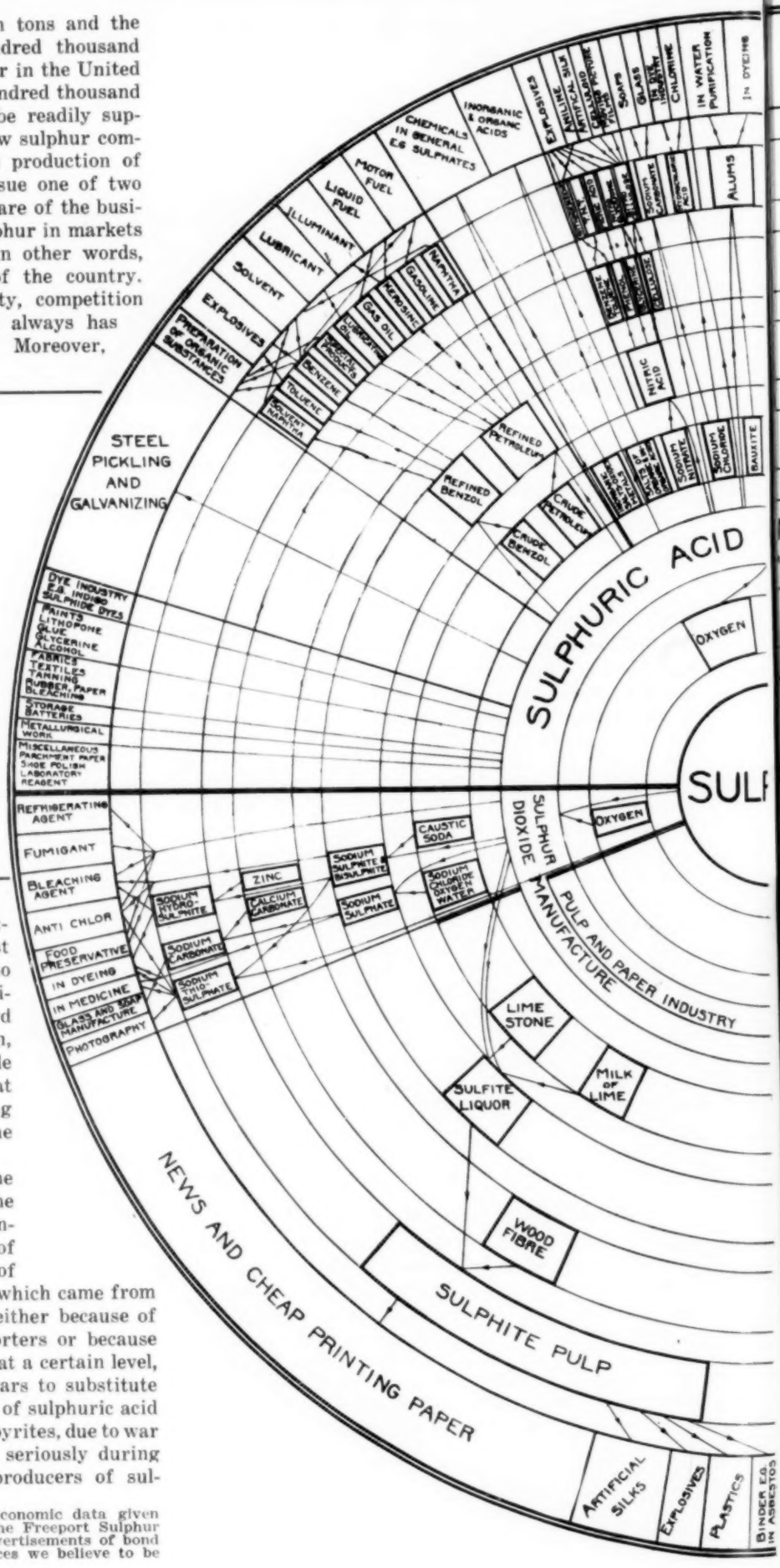
With reference to the first possibility, competition based on cut-throat slashing of prices always has proved disastrous to the whole industry. Moreover, the mining of sulphur by the Frasch process, to be carried out economically, must be conducted on a very large scale, so that even if a company under the conditions outlined above had obtained a third of a possible 500,000-ton consumption, this would not have insured profitable operation. The company has chosen what is surely the wiser course, in attempting to place its sulphur by increasing the total consumption in the industries.

It was possible to do this owing to the prevailing economic conditions. The United States had in recent years consumed annually, for the manufacture of sulphuric acid, upward of 500,000 tons of sulphur in the form of pyrites, most of which came from Spain. The older sulphur companies, either because of some agreement with the pyrites importers or because of a desire to hold the price of sulphur at a certain level, had not attempted seriously in past years to substitute sulphur for pyrites as the raw material of sulphuric acid manufacture. Importation of Spanish pyrites, due to war transportation conditions, fell off very seriously during the war years. This caused many producers of sul-

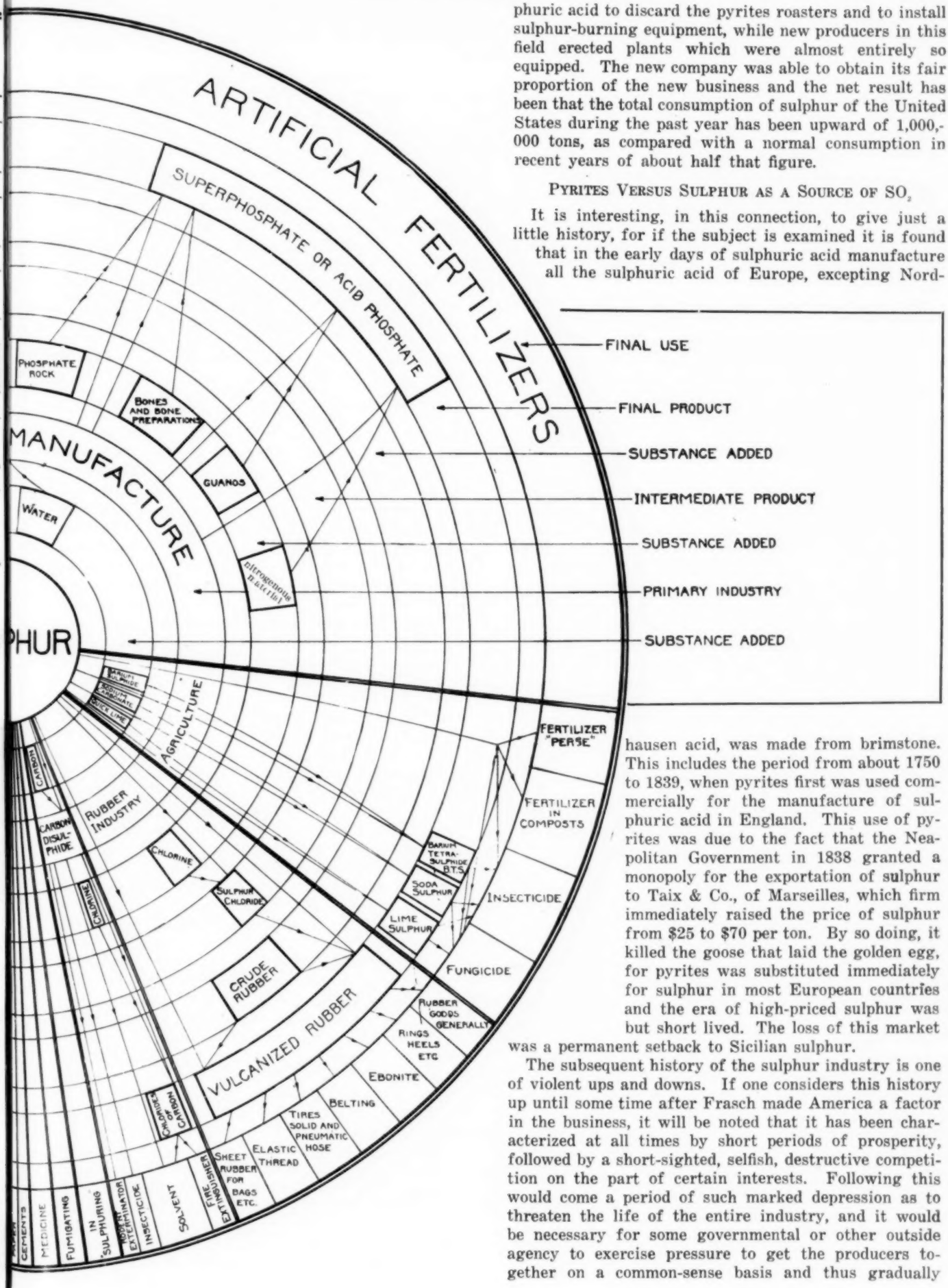
Sulphur Products Chart

Showing Primary Industry Entered, Intermediate and Final Products as Well as Final Use.

(Prepared by Mary D. Davis)



[3] It may be stated, in passing, that any economic data given regarding either the Union Sulphur Co. or the Freeport Sulphur Co. are subject to the usual statement on advertisements of bond sales; that is, "they are gathered from sources we believe to be reliable, but are not guaranteed by us."



phuric acid to discard the pyrites roasters and to install sulphur-burning equipment, while new producers in this field erected plants which were almost entirely so equipped. The new company was able to obtain its fair proportion of the new business and the net result has been that the total consumption of sulphur of the United States during the past year has been upward of 1,000,000 tons, as compared with a normal consumption in recent years of about half that figure.

Pyrites Versus Sulphur as a Source of SO_2

It is interesting, in this connection, to give just a little history, for if the subject is examined it is found that in the early days of sulphuric acid manufacture all the sulphuric acid of Europe, excepting Nordhausen acid, was made from brimstone. This includes the period from about 1750 to 1839, when pyrites first was used commercially for the manufacture of sulphuric acid in England. This use of pyrites was due to the fact that the Neapolitan Government in 1838 granted a monopoly for the exportation of sulphur to Taix & Co., of Marseilles, which firm immediately raised the price of sulphur from $25 to $70 per ton. By so doing, it killed the goose that laid the golden egg, for pyrites was substituted immediately for sulphur in most European countries and the era of high-priced sulphur was but short lived. The loss of this market was a permanent setback to Sicilian sulphur.

The subsequent history of the sulphur industry is one of violent ups and downs. If one considers this history up until some time after Frasch made America a factor in the business, it will be noted that it has been characterized at all times by short periods of prosperity, followed by a short-sighted, selfish, destructive competition on the part of certain interests. Following this would come a period of such marked depression as to threaten the life of the entire industry, and it would be necessary for some governmental or other outside agency to exercise pressure to get the producers together on a common-sense basis and thus gradually

put the industry again on its feet.[1] Since the time when Frasch made possible America's sulphur industry the stability of the whole industry has been much greater. While at the present time there is an extremely lively competition among the companies for business, there is every reason to believe that American common sense, spirit of fair play, and co-operation will prevent this competition going to the extent of threatening the industry itself, as has happened many times in the past. Present indications are that all the sulphur companies are pursuing an enlightened policy, in that all are doing more or less research and development work having as its ultimate object the opening up of broader markets for sulphur, of which sulphuric acid manufacture affords but one.

Advantages of Sulphur Over Pyrites

For sulphuric acid manufacture sulphur has many very marked advantages over pyrites. Using pyrites means handling into the works a comparatively large quantity of material, its slow combustion in expensive roasters, a certain inevitable dust nuisance and the disposal of a large tonnage of cinder. As against this, sulphur of less than one-half the weight of pyrites for a given tonnage of acid produced is handled into the works, is burned cleanly in inexpensive equipment and leaves no residues to be taken care of. Sulphur is constant in composition, and its freedom from arsenic and other impurities allows the production of a purer acid. It is also claimed that, in practice, the burning of sulphur means a higher rate of production for a given size of lead chamber space.

These acknowledged advantages of the use of sulphur over pyrites for sulphuric-acid manufacture have been demonstrated by the willingness of acid producers to pay a higher price per unit for elementary sulphur than for combined sulphur in the form of pyrites. An example of this is the fact that one of our largest and best organized chemical companies, in making a large contract, chose sulphur over pyrites for sulphuric-acid manufacture, where the differential in offered prices was 8c. per unit of sulphur.

When one considers the present high prices of labor, the uncertainty of the copper market and the fact that sulphur may be purchased in a competing market, from concerns which have large stocks on hand, so that delivery is certain, it would seem to be a wise business policy to use sulphur rather than pyrites for sulphuric-acid manufacture even with a very large differential in price. This is especially true when one considers the other side of the situation—namely, that in buying imported pyrites the consumer is putting himself at the mercy of one large set of interests which, while it may at the present time offer pyrites at low prices and even below actual cost, will almost certainly at some time in the future reap its profit by much higher prices. It is said that imported pyrites has been offered for large contracts in this country at about 10c. per unit of sulphur, ex-vessel, Atlantic seaboard, while at the same time pyrites was selling in England, much nearer the base of supplies, at 20c. to 22c. per unit of sulphur. It reminds one somewhat of the tactics of Standard Oil in the old days before "trust-busting" became fashionable with politicians; and everyone knows that those who bought cheaply when the company was extinguishing a competitor never reaped any permanent advantage, but later more than paid for temporary reductions in price.

Sulphur is today one of the few substances which have not risen in price since pre-war days. In fact, sulphur is cheaper today than at any other time in the history of the industry. The price for large contracts is about $20 per ton, Atlantic seaboard. This makes sulphur one of the cheapest raw materials available and should, it would seem, greatly extend its usefulness. Sulphur as mined and sold by all three companies is of remarkably high grade. In fact, many so-called C.P. chemicals do not possess the purity of crude sulphur, as sold by these companies. The sulphur is free from arsenic, selenium and tellurium, and often for days at a time wells will yield a product running higher than 99.9 per cent sulphur, as calculated on a moisture-free basis; in fact, sulphur companies selling the crude sulphur on contracts guarantee the purity to be over 99 or 99½ per cent.

Effect of Traces of Petroleum on Combustion

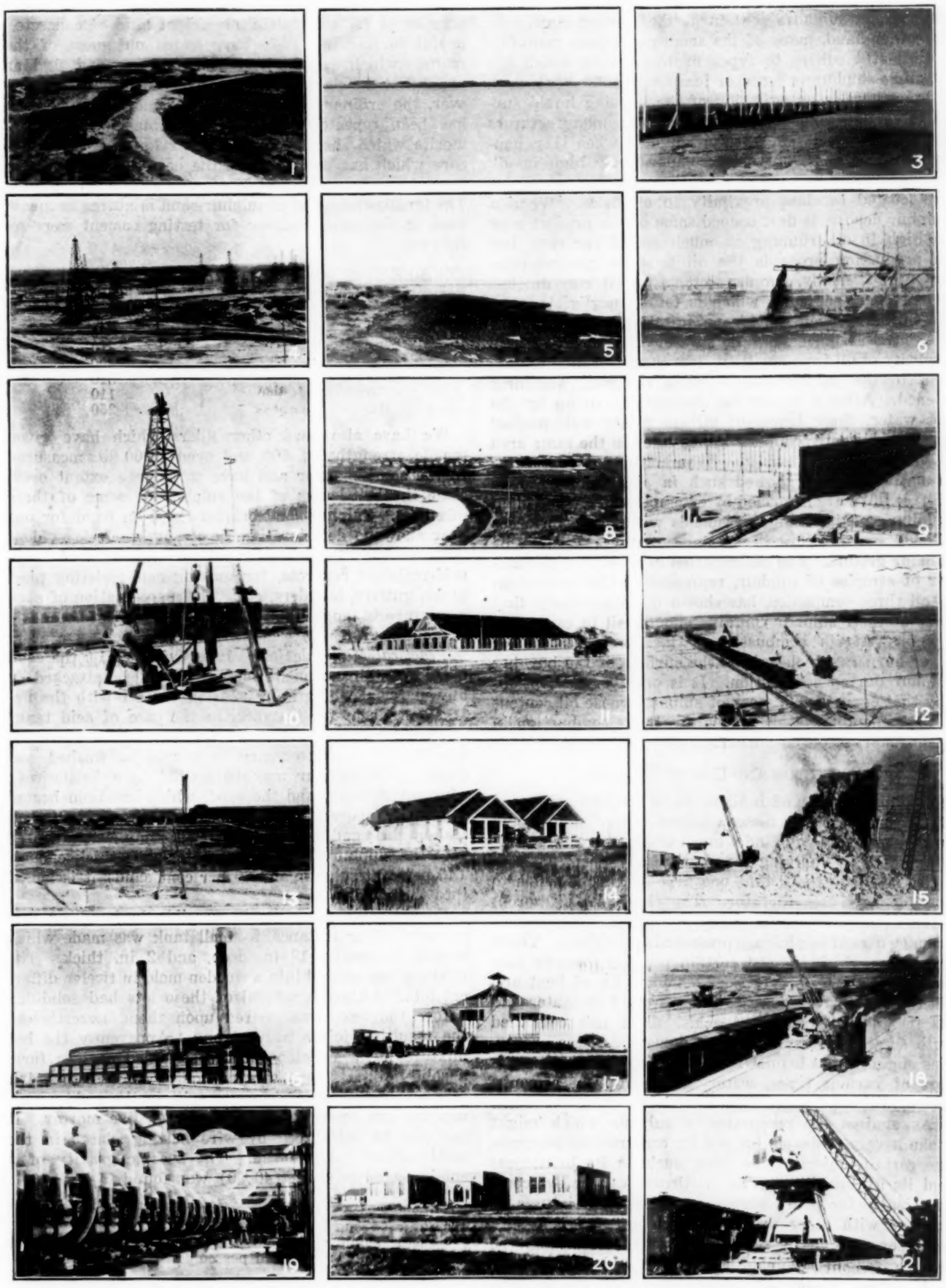
One impurity occurring in traces in the sulphur of all three companies is oil. There is a dearth of information in the technical literature respecting the subject of oil in sulphur. Since the effect of this impurity is very interesting, it is appropriate to discuss it here. The peculiar effect of oil is its influence on the burning qualities and also on the color and odor of sulphur. *A priori*, one would not assume that mere traces of a combustible substance like petroleum oil could affect adversely the combustion of another combustible substance like sulphur, but such is indeed the case.

If one will make a simple experiment by attempting to burn two small lots of sulphur, one being chemically pure and the other containing 0.2 per cent of petroleum oil, he will note the following phenomena: The pure sulphur will burn quietly until it is totally consumed; the sulphur containing the oil will burn for a very short time, when it will be observed that a thin, elastic film is being formed over its surface. Very soon combustion is taking place only in spots, and within an exceedingly short time the flame goes out, although only a small percentage of the sulphur has been consumed. The explanation is quite simple. Sulphur and oil at a moderate temperature react together to form asphalt, and if the reaction is carried to completion the final result is carbon.

In the burning of sulphur containing oil the oil reacts with the sulphur to form an asphaltic material, which quickly spreads as a film over the surface. The result, as combustion proceeds, is a film of carbon over the surface of the sulphur. The ignition temperature of carbon, or of the intermediate asphaltic material, is so much higher than that of sulphur itself or than the temperature developed during the burning of the sulphur that this film is not ignited and consequently the whole flame is extinguished.

The remedy for burning such sulphur is also quite obvious. If the devices for sulphur combustion are such as to agitate the surface of the burning sulphur or in any other way break this film of asphaltic material, no difficulty will be experienced. Acid manufacturers who use mostly modern types of sulphur burners, such as the rotary or cascade type, which allow the sulphur to drop from one level to another, have absolutely no difficulty in burning sulphur containing 0.2 per cent of oil, which figure represents more oil than any of the

[1] In this connection, see Frasch, Perkin Medal Address, Met. & Chem. Eng., vol. 10, No. 2, pp. 73-82, and *J. Ind. Eng. Chem.*, vol. 4 (1912), p. 139.



General Views Showing Topography, Figs. 1, 2, 5, 8.
Method of Loading for Shipment, Figs. 12, 15, 18, 21.
Houses, Pavilion and Hospital, Figs. 11, 14, 17, 20.

Sulphur Tank Storage System, Figs. 3, 6, 9.
Well Driving Equipment, Figs. 4, 7, 10.
Exterior and Interior Views of Power House, Figs. 13, 16, 19

commercial sulphurs contain at the present time. On the other hand, many of the small paper-pulp manufacturers still adhere to types of burners in which the burning sulphur is more or less quiescent. With such a type there is no agitation of the burning liquid surface, so that some of these paper-pulp manufacturers have had difficulty in burning sulphur when they happened to obtain a shipment comparatively high in oil.

The sulphur deposits of all three operating companies are located in close proximity to oil fields. When a sulphur deposit is first opened some of the product may be high in oil, running as much as 0.2 per cent, but as production proceeds the oil becomes progressively lower until finally, for days at a time, it may amount to only 0.04 per cent, which is totally negligible, even for burners which provide no agitation of the surface. We have assumed that hot water carried this small quantity of oil from small crevices in the oil-sand formation to the sulphur below when the well was first opened. After a region has become heated up by the hot water, these traces of oil are pretty well washed out; consequently, sulphur mined later in the same area is virtually free from it. Examination of drill cores of native sulphur showed such *in situ* sulphur to be oil-free. We are informed by ex-employees of the Union Sulphur Co. that this corresponds with the experiences of that organization in heating up any new area of sulphur ground. The examination of a very large number of samples of sulphur, representing the production of all three companies, has shown quite positively that none of their sulphur contains enough oil to cause any difficulty in its combustion with rotary burners or other burners which agitate the surface of the burning sulphur during combustion. It is only very exceptionally that one will find a car of sulphur whose oil content is high enough to make difficulties in its combustion in a stationary type of burner.

Properties and Uses of Sulphur

Sulphur is now and is likely to be for some time one of our cheapest raw materials, and accordingly should and undoubtedly will find a much wider range of usefulness. It is by studying the physical and chemical properties of a substance that one first obtains ideas as to possible new uses therefor. The chief physical properties of sulphur are tabulated in Table I. The present tonnage uses of sulphur are presented in the chart. Those properties which suggest certain possible tonnage uses for sulphur are its very poor conductivity of heat and electricity, its resistance to being wetted by water and its inertness toward most acids, all of this combined with a fair degree of physical strength. These properties suggest heat-insulating materials, electrical insulators of various types, water- and acid-proof cements, and acid-proof construction materials.

As against the properties of sulphur which might make it very desirable for certain construction purposes are certain objectionable ones, such as its brittleness and its flammability. The brittleness can be overcome sufficiently for many purposes by making mixtures of sulphur with other materials, such as sand, asbestos, or paper pulp, or by reinforcing with wire screen. In many cases the flammability is not a serious objection.

A survey of the literature, especially the patents, on the subject of sulphur mixtures reveals that almost every conceivable thing has been suggested as a perfective admixture for sulphur to obtain a material which has all the air- and acid-resistant properties one could desire or to get a completely resistant kind of concrete useful in building. We have tested out most of the recipes which appeared to be promising and find as usual that the claims have been much overstated. However, the ordinary mixture of sand and sulphur which has been repeatedly mentioned in the literature has merits which should make it better known. The mixture which has seemed to us the best for most uses is that of 40 of sulphur and 60 of sand (parts by weight). The tensile strengths of sulphur-sand mixtures as measured in the usual manner for testing cement were as follows:

TENSILE STRENGTHS OF SULPHUR-SAND MIXTURES

Percentage of Sulphur by Weight	Tensile Strength, Lb. per Sq.In.
25	90
35	310
40	400
45	310
50	110
100	250

We have also used other fillers which have given tensile strengths of 800 and even 1,100 lb. measured in the same manner and have to a large extent overcome the brittleness of the sulphur in some of these mixtures. Sulphur-sand briquets kept on hand for one year show no deterioration in strength. It is evident that the 40-60 sulphur-sand mixture can be used as an acid-resistant concrete, for making acid-resisting pipe, tanks, gutters, launders, etc. The manipulation of such a mixture is much like that of pouring concrete and is as follows:

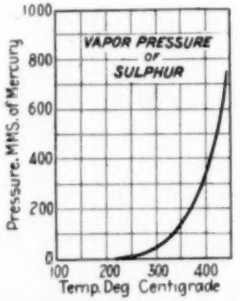
Practical Manipulation. It is evident that the sand should contain no constituent which will be attacked by any material which is to come in contact with the finished product; for instance, in the case of acid tanks it should be free from limestone or other acid-soluble constituents. If necessary, it should be washed and dried. The sulphur may be melted in a kettle with constant stirring, and the sand, which has been heated separately, poured into it while the stirring is continued. Unless the sand is heated, it will lump when poured into the sulphur. When the material is thick enough (40 per cent sulphur and 60 per cent sand) it is ladled into the molds.

Considerable flexibility is possible in handling this material. For instance, a small tank was made which was 2 ft. square, 18 in. deep, and 2 in. thick. The mixture was poured into a wooden mold in twelve different lots. Although several of these lots had solidified before the next was poured upon them, nevertheless the resulting joints were strong. Apparently the hot mixture melts sufficient of the solidified part to form a solid joint. There was no contraction of the tank as a whole and no tendency to split in the mold. This mixture can be worked with a trowel, like mortar. It can also be reinforced by wire netting placed in the mold before it is poured. The specific gravity of a sulphur-sand mixture (40:60) was found to be 2.46.

Weight of 1 cu.ft.	154 lb.
Weight of sulphur required per cu.ft.	62 lb.
Weight of sulphur required per cu.yd.	1,670 lb.

Taking the value of sand as $1 per cu.yd. and of sulphur as $20 per ton, the price of the materials per cu.yd. will be about $18. It may be possible to decrease appreciably the amount of sulphur necessary and hence

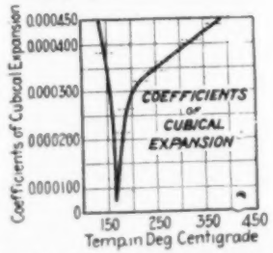
THE PHYSICOCHEMICAL PROPERTIES OF SULPHUR



VAPOR PRESSURE CURVE [1]

FORMS OF SULPHUR

	Sp.Gr.
Crystalline	
a. Rhombic. Ordinary form stable below 96° C. (205° F.)	2.07[1]
b. Monoclinic. Stable above 96° C. (205° F.)	1.96[1]
c. Milk of Sulphur. Formed, *e. g.*, by action of diluted acids on polysulphides. Generally called amorphous, but shown by Smith and Brownlee to be crystalline[2]	
There are several other modifications of crystalline sulphur of scientific interest but not of general importance.	
Liquid. At 113° C. (235° F.)	1.81[1]
Contains	
Sulphur (liquid, soluble), S_λ	
Sulphur (liquid, insoluble or amorphous), S_μ	
The proportion of S_μ to S_λ increases with the temperature.	
Amorphous. S_μ (solid)	1.89[3]
Plastic Sulphur. Formed by heating sulphur above viscous stage, 162° C. or 324° F., and cooling quickly	1.88[3]
Elastic Sulphur. Formed by heating sulphur above 400° C. or 752° F. and pouring in a thin stream into liquid air. Its elastic properties are soon lost.	
Black Sulphur. "When sulphur mixed with very little oil is thrown into a hot platinum dish, a black substance is obtained which has been looked on as a modification of sulphur. The product contains 55% of sulphur and 33% carbonaceous material."—Watts, *Dictionary of Chemistry.*	



The coefficients of cubical expansion over various ranges of temperatures are shown at horizontal broken lines

ELECTRICAL CONDUCTIVITY [1]

Measured as reciprocal value of resistivity in ohms of 1 cm. cube.

C.	Temp. F.	Conductivity
22	72	1×10^{-17}
69	156	0.254×10^{-15}
115	239	0.105×10^{-11}
130	266	0.5×10^{-10}
430	806	0.1×10^{-7}

Compare:

Porcelain	1×10^{-14}
Mica	1×10^{-12}
Ebonite	1.5×10^{-11}

FRICTIONAL ELECTRICITY

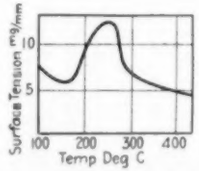
when rubbed with practically any other substance, *e.g.*, glass, fur, silk, wool or hard rubber—sulphur becomes charged with negative electricity.

COEFFICIENT OF LINEAR EXPANSION [1]

Temp. C.	Temp. F.	Ex. Coeff.
0–13	32–56	0.000046
13–50	56–122	0.00007
50–78	122–173	0.00009
78–97	173–207	0.0002
97–110	207–230	0.001

SURFACE TENSION [4]

Temp. C.	Temp. F.	Surface Tension, mg./mm.
120	248.0	5.71
131	267.8	6.12
146	294.8	6.05
195	383.0	6.62



APPROXIMATE CURVE OF SURFACE TENSION

COMPRESSIBILITY [5]

Average fractional change of volume caused by 1 megabar change in pressure between 100-500 megabars 0.0000125.

1 megabar = 0.987 atmosphere

CONDUCTIVITY OF HEAT [1]

Measured as the number of gram-calories transmitted in 1 second through a plate 1 cm. thick and having surfaces 1 sq.cm. in area when opposite faces differ in temperature by 1°C.

20–100° C. (68–212° F.)	0.0006
Compare:	
Ice	0.002
Copper	1.00

International Atomic Weight, 1920 = 32.06

Vapor Density:

At boiling point corresponds approximately to formula S_{8}.[13]

At 1,000 deg. C. (1,832 deg. F.) corresponds approximately to formula S_2.

ECONOMICS OF NATURAL SULPHUR

Until 1900, 95% of world's supply from Sicily
In 1912, 50% of world's supply from Sicily
In 1917, 14% of world's supply from Sicily
In 1917, 80% of world's supply from U. S. A.

UNITED STATES EXPORTS AND IMPORTS

1909 exports	37,142 long tons
1909 imports	30,589 long tons
1918 exports	131,092 long tons
1918 imports	82 long tons

UNITED STATES PRODUCTION

1894,	494 long tons	1909,	303,000 long tons
1899,	1,590 long tons	1914,	347,491 long tons
1904,	196,888 long tons		

1919 TEXAS GULF SULPHUR CO.

Only nine months production after start
348,380 long tons

PROPERTIES OF COMMERCIAL SULPHUR

Insoluble in water

Insoluble in most acids

Tensile strength, 200 lb. per sq.in. (approx.)
Heat conductivity, low: ½ that of cork, ¼ that of ice
Electrical conductivity lower than that of practically any other solid substance
Melting point, depending on conditions, 110.2—119.25 deg.C. (230.4—246.7 deg. F).
Ignition temperature, 248 deg. C. (478 deg. F).[7]
Boiling point, 444.6 deg. C. (832.3 deg. F.)[6]

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[8] Calculated from vapor pressure curve. See also J. W. Richards, Metallurgical Calculations (2d ed.).

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[13] Gmelin-Kraut, Handbuch der anorganishen Chemie.

MELTING POINT [1]

Type of Sulphur:	Temp. C.	Temp. F.
Rhombic	112.8	235.
Monoclinic	109.25	246.7

Natural freezing point S_λ and S_μ in equilibrium (96.3% S_λ, 3.7% S_μ), 110.2 deg. C. (230.4 deg. F.).

SPECIFIC HEAT [1]

Type of Sulphur	Temp. C.	Temp. F.	Sp.Ht.
Rhombic	0–95°	32–203°	0.1751
Liquid	160–201	320–393	0.279
	201–233	393–451	0.331

HEAT OF COMBUSTION [1]

	G. Cal. per g. S.	B.t.u. per Lb.
$S + O_2 \rightarrow SO_2$	2200	3960
$S \rightarrow H_2SO_3$ (dilute)	2450	4410
$S \rightarrow H_2SO_4$ (dilute)	4450	8010

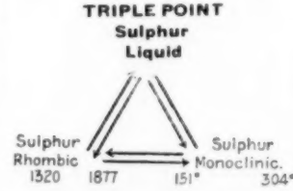
HEAT OF VAPORIZATION [8]

Temp. C.	Temp. F.	G. Cal. per G.	B.t.u. per Lb.
444.6°	832.3°	70 (Approx.)	126

TRANSITION TEMPERATURE [1]

S Monoclinic ⇆ S Rhombic

Pressure Kg./Sq.cm.	Pressure Lb./In.	Temp. C.	Temp. F.
10.6	15	96°	204.8°
123	175	100	212.2
638	907	120	248
1350	1920	150	302

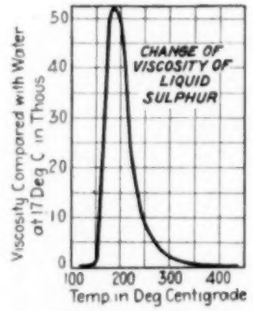


HEATS OF SOLUTION IN CS_2 [9]

	G. Cal. per g.	B.t.u. per Lb.
Dilute solution	—11.89	—21.4
Saturated solution	—11.55	—20.9

HEATS OF FUSION [10]

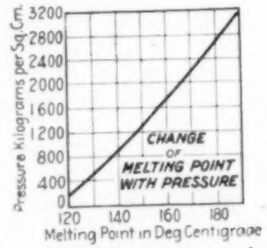
	G. Cal. per g.	B.t.u. per Lb.
Rhombic at 100° C. (212° F.)	14.9	26.8
Monoclinic at 100° C. (212° F.)	11.5	20.7
To form pure liquid sulphur (S_λ)		
From rhombic	14.5	26.1
From monoclinic	11.1	20.0



CHANGE IN VISCOSITY WITH TEMPERATURE [1]

Solubilities in Various Solvents [11]

	Temp. C.	Temp. F.	Solubility, G. in 100-g. Solution
Amyl alcohol	95	203	1.5
	110	230	2.1
Aniline	89.5	193.1	8.3
	130	266	46.2
Benzene	25	77	2.1
	70	158	8.0
Carbon disulphide	—20	—4	10.5
	—10	14	13.5
	0	32	18
	20	68	29.5
	50	122	59
	100	212	92
Carbon tetrachloride	25	77	0.86
Chloroform	22	71.6	1.2
Coal-tar oil, sp.gr. 0.87	15	59	2
	100	212	13
Sp.gr. 1.02	15	59	6.5
	110	230	53.5
Ethyl ether	23.5	74.3	0.97
Linseed oil	15	59	0.4
	160	320	9.0
Olive oil (Sp.gr. 0.885)	15	59	2.2
	130	266	30
Sulphur chloride	0	32	11
	55.2	131.4	43
	86	186.8	89
Phenol	175	346	26.7
Toluene	23	73.4	1.48
Turpentine (oil of)	16	60.8	1.33



CHANGE OF MELTING POINT WITH PRESSURE [1]

the cost by imbedding larger pieces of crushed rock or some such substance in the mass. Tests of the material in sea water are being made, but it is too early to give results. It is apparently standing up well to date.

Pipes cast of this sulphur-sand mixture show no deterioration after one year in 5 per cent hydrochloric or 5 per cent sulphuric acid. The ordinary organic acids have no effect on such a mixture. The following extract is pertinent in this connection:

THE USE OF SULPHUR AND SAND IN SEWER PIPE JOINTS[1]

In constructing a main line 36-in. sewer for the conveyance of acid waste for a pulp mill in Quebec the question arose as to what material should be used in pouring the joints. Cement was out of the question on account of the deteriorating effect acid would have upon it. A number of mills were corresponded with upon the subject, but no very satisfactory method was recommended.

Ultimately the use of sulphur and sand was suggested by the engineering department. Lead wool was considered but rejected upon the ground that the cost was high. On the other hand, sand was available on the ground from excavations and sulphur could be purchased at the dockside in Three Rivers.

The method used was as follows:

An ordinary iron boiling cauldron over an open wood fire was used for heating the sulphur and sand. The proportions were one to one. The whole was heated until the sulphur melted and a semi-liquid mass formed. Three pipes were placed vertically in the trench and by means of a galvanized conductor pipe bent at one end to fit into the flange of the pipe the mixture was poured from a ladle on the top of the trench directly into the joint. The joints of each section of the three pipes in the trench were then poured in the ordinary manner with the use of a runner.

The insides of the joints were pointed with wet clay. The joints cast and became solidified in about one hour after pouring. The length of time for solidification of course depended upon the coldness of the weather.

The joints so far have been all that could be desired, having neither blowholes nor cracks. The solidified sulphur and sand is extremely hard and the only impression made on it with a large knife was to scrape fine particles away. In appearance it is almost metallic.

One possible tonnage use for sulphur which has been arousing a great deal of interest in the last two years is its application as a fertilizer. There are two methods of application which have received attention from experiment stations. During the war, when sulphuric acid was needed for munition manufacture, Lipman, of the New Jersey Experiment Station, showed that if sulphur is composted with ground raw phosphate rock the phosphate is rendered available within a reasonably short time. Bacteria in the soil oxidize the sulphur to sulphuric acid, which acts on the raw phosphate to give available plant food. It is thus possible to make available as high a percentage of phosphoric acid as is found in commercial acid phosphate. The work has been confirmed by other experiment stations and would undoubtedly have been of great importance if the shortage of sulphuric acid had continued. Lipman has since improved the procedure by isolating and growing pure cultures of the most active sulphur oxidizing bacteria and has prepared sulphur inoculated with these. Such a product is put on the market under the name "Bac-Sul" and it is understood that the Union Sulphur Co. is interested in its sale. Although we believe that a product of this kind will do all that is claimed for it, it is doubtful whether it means any immediate tonnage outlet for sulphur. Competent agricultural authorities advise that it is nearly impossible to get the American farmer to do composting and at best the introduction of any new type of fertilizer is a slow and tedious process. The other use of sulphur as a fertilizer consists in its direct application to the soil. The Oregon Agricultural College Experiment Station has shown very conclusively that certain soils in southern Oregon are immensely benefited in this way, so that the alfalfa crops have been greatly increased. Several of the other state experiment stations have reported the same experience for certain types of soils. In fact, results obtained by the use of sulphur as a fertilizer have in some cases been so remarkable as seriously to raise the question whether some of the standard theories on fertilizers will not have to be revised. Nearly all the experimental work through which phosphate has been given its high place as a fertilizer has been done with an acid phosphate containing considerable quantities of sulphates. Similarly, in experiments with potassium and ammonium fertilizers, the sulphates have often been used. Any change in growth or yield has been ascribed to the phosphates, the potassium or the nitrogen. The question now arises as to how much of this change in plant growth was due to the sulphur entirely apart from the other fertilizing constituents.

Correspondence with virtually all the experiment stations in the United States on the subject of sulphur as a fertilizer has elicited opinions which virtually all boil down to the following: Very many of our soils either contain enough sulphur for plant requirements or receive sufficient in the rainfall and other water. There are also very many soils on which sulphur would undoubtedly prove to be an advantageous fertilizer either because of a deficiency in sulphur or because sulphur during its oxidation would make available from the soil other needed plant foods. Work is either under way or in project in almost every experiment station in the country to obtain more knowledge on this subject, especially to find out what soils in each particular state have need of sulphur. It is probable that in time this may mean a tonnage market for sulphur, but when it is considered that there is today definite proof that the farmers of the country as a whole could use to their own profit at least ten times as much fertilizer as they do it will be realized that the building up of a tonnage use of any new fertilizer promises nothing large in the near future.

The greatest problem of the American sulphur industry at the present time is to obtain immediately available new tonnage outlets for sulphur. The solution of this problem would mean a continued prosperity to the sulphur industry and a continuance of low-priced sulphur for the greater chemical industry.

Mellon Institute of Industrial Research.
Pittsburgh, Pa.

[1] *Pulp and Paper Magazine*, vol. 17, 1920, p. 998.

Value of Magnesium Salts as Fertilizers

Magnesium plays an important rôle in the process of plant assimilation and it has been shown that the chlorophyll is an organic magnesium compound with a content of about 30 per cent magnesium. In a paper recently read before the German Chemical Society Dr. A. Jacob described the experimental work done during 1917-19 by the agricultural department of the Kalisyndicat on the influence of various magnesia-containing fertilizers on harvest yields and showed that potassium-magnesium sulphate and potassium chloride-kieserite ($MgSO_4.H_2O$) constitute efficient fertilizers for sandy and brackish soils.—*Chemical Trade Journal and Chemical Engineer*, Dec. 25, 1920.

Physical Properties of Nickel

Compilation of Literature References and Original and Unpublished Work on the Various Physical, Mechanical, Thermal, Electrical and Optical Properties of Pure Nickel

By PAUL D. MERICA
Superintendent of Research, International Nickel Co.

THE density and specific gravity of nickel vary greatly according to its chemical composition, physical condition and the mechanical treatment which it has received. Metal which has been reduced by carbon, or carbon monoxide, to a powder or sponge contains numerous voids and may have a density as low as from 7.7 to 8.0, values which have been obtained for powder and rondelles, or grain nickel.

Dense nickel, such as electro- or malleable nickel, will vary in density from 8.70 to 8.90, averaging about 8.84, which may be taken as quite closely representing the bulk of commercial material. This corresponds to 552 lb. per cu.ft., or 0.319 lb. per cu.in. (8.84 g. per cu.cm.).

Change of State

The melting point of nickel is given by the Bureau of Standards[1] as 1,452 deg. C. The element undergoes a magnetic transformation, accompanied possibly by a phase change at from 340 to 360 deg. C.[2,3] The transformation point in commercial nickel, containing impurities, is lower, usually in the neighborhood of 320 deg. C.[3,4] The boiling point of nickel has never been determined.

The heat of transformation is 1.33 cal. per gram according to Wüst,[5] and the heat of fusion 56.1 cal. per gram.

Specific Heat

Wüst[5] has recently determined the specific heat of nickel (analysis not given) from 0 to 1,520 deg. C. in cal. per gram per deg. C.; his results are given in Table I.

TABLE I. SPECIFIC HEAT OF NICKEL

Temperature	Mean Specific Heat $\frac{q_t - c_0}{t}$	True Specific Heat $\frac{dq}{dt}$
0	.....	0.1095
100	0.1147	.1200
200	.1200	.1305
300	.1252	.1409
320	.1263	.1430
330	.1306	.1294
400	.1304	.1294
500	.1302	.1294
600	.1301	.1294
700	.1300	.1295
800	.1299	.1295
900	.1299	.1295
1000	.1298	.1295
1100	.1298	.1296
1200	.1298	.1296
1300	.1298	.1296
1400	.1298	.1296
1451 (solid)	.1298	.1296
1451 (liquid)	.1684	.1338
1500	.1673	.1338
1520	.1668	.1338

Jaeger and Dieselhorst[6] determined the true specific heat at 18 and at 100 deg. C. of a sample of nickel containing Co 1.36, Fe 0.44, Mn 1.04, Cu 0.15, Si 0.06. They find the following values:

At 18 deg. C. = 0.1065 cal. per gram per deg. C.
At 100 deg. C. = 0.1160 cal. per gram per deg. C.

Schimpff[7] finds the following values of the mean specific heat of nickel containing 1.5 per cent Co, 0.6 per cent Fe and 97.9 per cent Ni:

At 17 to 100 deg. C., 0.1084 cal. per gram per deg C.
At 17 to —79 deg. C., 0.0973 cal. per gram per deg. C.
At 17 to —190 deg. C., 0.0830 cal. per gram per deg. C.

Thermal Expansivity

Guillaume[8] finds the thermal expansivity between 0 and 40 deg. C. of five bars of commercial nickel to be represented by the equation:

$$\frac{\Delta l}{l_0 t} = (a + bt)\ 10^{-6}$$

in which the values of the coefficients a and b had the following values:

	a	b
1	12.66	0.0055
2	12.52	0.0066
3	12.49	0.0070
4	12.49	0.0079
5	12.55	0.0054

Tutton[9] finds the following values of a and b for same equation, holding between 0 and 120 deg. C.:

$$a = 12.48,\ b = 0.0074$$

Between 0 and 300 deg. C. Harrison[10] finds that the expansivity of "pure nickel" can be represented by the following equation:

$$\frac{\Delta l}{l_0 t} = (12.80 + 0.0075t + 0.000035t^2)10^{-6}$$

Between 300 and 1,000 deg. C. Holborn and Day[11] give the following equation for the expansivity, as calculated from their measurement on a nickel of which no analysis is given:

$$\frac{\Delta l}{l_0 t} = (13.46 + 0.0033t)10^{-6}$$

Thermal Conductivity

The best determinations of the thermal conductivity of nickel are those of Lees[12] on electrolytic nickel, and of Jaeger and Dieselhorst[6] on nickel of composition 1.36 Co, 0.44 Fe, 1.04 Mn, 0.15 Cu, 0.06 Si. The values obtained by them are:

Lees:

$K_0 = 0.140$ calories per second per cm. per deg. C.
$K_{18} = 0.140$ calories per second per cm. per deg. C.

Jaeger and Dieselhorst:

$K_{18} = 0.142$ calories per second per cm. per deg. C.
$K_{100} = 0.138$ calories per second per cm. per deg. C.

Fig. 1, curve 1, gives the results of determinations of Lees[12] on 99 per cent nickel bar and curve 2 by Angell[13]

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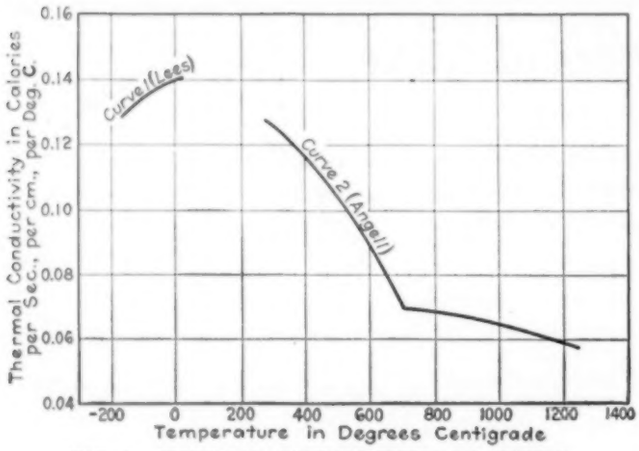

FIG. 1. THERMAL CONDUCTIVITY OF NICKEL

on a nickel rod from Boker (no analysis) of the thermal conductivity at higher and lower temperatures.

Electrical Resistivity

A number of precise determinations of the electric resistivity of nickel have been made, but the nickel used was in many cases quite impure and the values of the resistivity so obtained are much higher than the value for pure nickel. Table II gives several of the values which have been observed.

The most probable value for the resistivity of pure nickel from these determinations is the lowest, that of Copaux; with this lowest value is associated also the highest temperature coefficient (also the most probable). Other values are higher due to the presence of impuri-

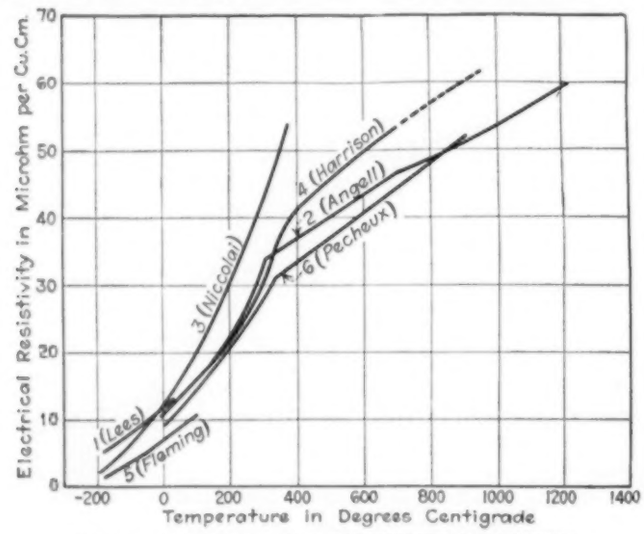

FIG. 2. ELECTRICAL RESISTIVITY OF NICKEL

ties which depress also the value of the temperature coefficient.

Fig. 2 gives the results of several determinations of the electrical resistivity at higher and lower temperatures.

These are as follows: Curve 1 is by Lees,[12] on a 99 per cent Ni bar. Curve 2 is by Angell[13] on a nickel rod from Boker (no analysis). Curve 3 is by Niccolai[5] on Kahlbaum nickel (no analysis). Curve 4 is by Harrison[15] on a "nickel wire." Fig. 3 gives the results of one series of determinations of the influence of temperature on the temperature coefficient of resistivity by Somerville.[17] At the transformation point the resistivity-temperature curve changes its slope and there is a marked change in the value of the temperature coefficient.

The Driver-Harris Co. reports its 99 per cent nickel (Grade A) wire as having a resistivity of 64.3 ohms per mil-foot (10.68 microhm per cu.cm.) at 24 deg. C., with a temperature coefficient at 24 deg. C. of 0.0041. Other grades of malleable nickel of higher manganese content have higher values of resistivity and temperature coefficient; thus, Grade D nickel, containing 4.5 per

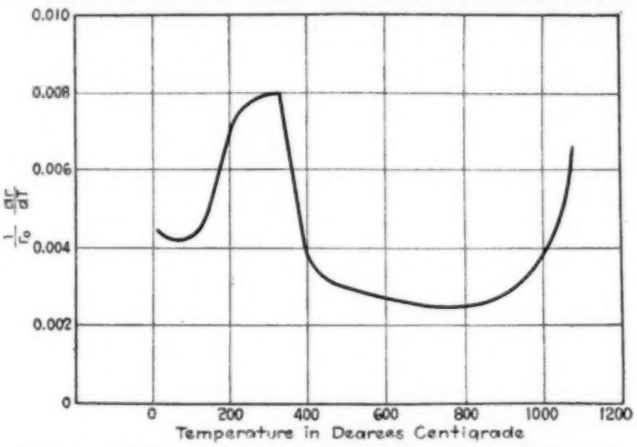

FIG. 3. TEMPERATURE COEFFICIENT OF ELECTRICAL RESISTANCE ACCORDING TO SOMMERVILLE[17]

cent Mn, has a resistivity of 20.0 microhm per cu.cm., with a temperature coefficient of 0.0020.

Thermo-Electromotive Force

The curves of Fig. 8 give the results of determinations of the thermo-electromotive force of nickel to platinum, lead, copper and silver. These are as follows:

Nickel against silver is, according to determinations of Hevesy and Wolff[19] on nickel wire, no analysis given, furnished by the Vereinigte deutsche Nickel Werke. Ni: Pt is calculated from the preceding results on the Ni: Ag couple, together with those of Holborn and Day on the Ag: Pt couple. Ni: Cu is according to determinations of Pecheux[20] on nickel wire of the following composition: Cu 0.20, Fe trace, Co 0.15, C and Si none; total impurities 0.35. Ni to Pb is according to determinations of Dewar and Fleming[21] on Mond nickel. The electromotive force developed is such that the current flows at the 0 deg. C. junction from the Ag, the Cu or the Pt to the Ni, when the emf. is positive.

Magnetic Properties

Nickel is ferromagnetic at ordinary temperatures and up to the temperature of its magnetic transformation,

TABLE II. ELECTRICAL RESISTIVITY OF NICKEL

Reference	Material	Electrical Resistivity Microhms per c.c.	Temperature Coefficient	Curve No in Fig. 2
Fleming[14]	Electrolytic, no analysis given. Annealed in hydrogen and drawn into wire	6.926 at 0° C.	0.0061 (0–100° C.)	5
Copaux[2]	Pure, reduced from oxalate, no analysis	6.4 at 0° C.	0.0066 (0–100° C.)	..
Campbell[15]	Purchased in Germany in 1901	8.0 at 0° C.	..	..
Pecheux[3]	0.20 Cu, 0.15 Co, no C or Si, trace Fe; 0.35 total impurities	9.0 at 0° C.	0.0058 (0–100° C.)	6
Ruer and Kaneko[16]	Kahlbaum, 0.035 C	7.7 at 0° C.	..	..
Jaeger and Dieselhorst[6]	1.36 Co, 0.44 Fe, 1.04 Mn, 0.15 Cu, 0.06 Si	11.76 at 18° C.	0.0044 (1–100° C.)	..

340 to 360 deg. C. Above this temperature it is paramagnetic and follows Curie's law.[20] Fig. 5 gives the results of some magnetic tests of nickel. In this figure curve 1 shows the induction curve for malleable nickel (International Nickel Co.) containing Ni 98.82, Cu 0.18, Fe 0.46, Mn 0.27, C 0.11, Si 0.13, S 0.022, as determined by the Burrows method. Curve 2 gives the permeability curve for same material. Curve 3 represents the induction of nickel of unknown composition as determined by Perkins,[21] while curve 4 gives the induction of nickel of unknown composition reported by Ewing.[22]

The susceptibility of nickel in any direction is markedly diminished by the application of a tensile stress and augmented by that of compressive stress in that direction.

The permeability of nickel increases with temperature up to 300 to 340 deg. C. (Ewing[23]).

Solution Potential

The true reversible potential of nickel in a normal aqueous nickel sulphate solution is given by Schoch[25] as 0.48 volt, measured against the normal calomel electrode. Schoch attributes the higher values obtained by other investigators to occluded hydrogen.

Schweitzer[26] gives the value 0.612 volt for the potential of nickel powder in contact with N/1 $NiSO_4$ and 0.596 volt for nickel powder in contact with N/1 $NiCl_2$, both measured against the normal calomel electrode.

Measurement has been made by N. Isgarischew[27] of the potential of nickel against a solution of $NiCl_2$ in methyl alcohol. The combination was:

Ni: 0.0277N $NiCl_2$: 0.02698N KCl: Hg_2Cl_2: Hg

At a temperature of 25 deg. C. the potential difference was 0.247 volt.

Nickel becomes markedly passive—i.e., it behaves like a noble metal—to a greater degree than do other metals of high solution potential. This condition

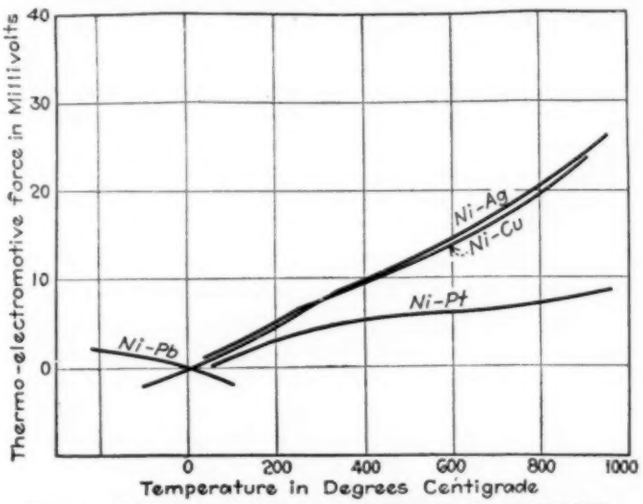

FIG. 4. THERMO-ELECTROMOTIVE FORCE OF NICKEL

of passivity may often be destroyed by slight changes in the chemical environment or by scratching or mechanical shock. Pure nickel as an anode is readily rendered passive in electrolytes containing salts of oxygen acids, especially at high current densities. The presence of impurities in the anodes as well as of the chlorides or fluorides in the electrolyte tend to prevent passivity. Coincident with the establishment of passivity, there is a pronounced drop in the solution potential.

Optical Properties

One of the most important commercial properties of nickel is its ability of taking and retaining a high polish and of reflecting a large percentage of light incident on such a polished surface. For example, this is one of the properties which make the metal valuable

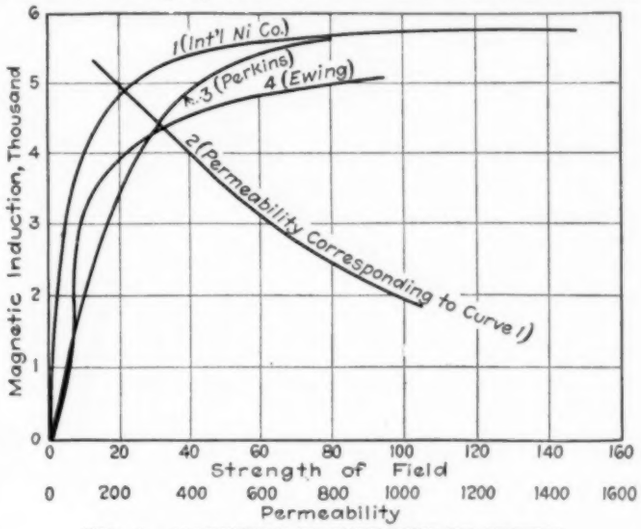

FIG. 5. MAGNETIC PROPERTIES OF NICKEL

for electroplating. In Table III are given the best values of the reflectivity of both nickel and Monel metal; those of the Bureau of Standards are recent (1920) and were obtained on samples of typical commercial rolled materials.

TABLE III. REFLECTIVITY OF NICKEL AND MONEL METAL

Wave Length of Light. Microns		Hagen and Rubens Values on Electrically Deposited Nickel. Per Cent	Bureau of Standards Values (1920) on Commercial Rolled Nickel. Per Cent	Bureau of Standards Values (1920) on Commerical Rolled Monel. Per Cent
0.42		56.6	....	....
0.50		60.8	61.5	57.7
0.55		....	63.2	59.0
0.60		64.9	64.0	60.1
0.65		....	65.1	61.6
0.70		68.8	67.1	62.8
0.75		....	68.5	64.5
0.80		....	67.2	67.2
1.00		....	72.5	72.5
2.00	infra-red	....	83.8	83.8
3.00		....	88.7	88.7
4.00		....	91.0	91.0

TABLE IV. MODULUS OF ELASTICITY OF NICKEL

Temperature, Deg. C.	Modulus of Elasticity in Torsion, Kg. per Sq.mm.	Young's Modulus Kg. per Sq.mm.
20	.....	22,000
27.5	7,300	.....
96	.....	21,300
110	6,430	.....
200	6,860	.....
222	.....	20,300
300	7,390	.....
329	.....	17,800
400	7,120	.....
401	.....	15,700
465	.....	11,900
600	6,080	.....
800	4,940	.....
1,000	3,730	.....
1,200	2,900	.....
1,300	2,480	.....

Meyer[28] gives the following values for the other optical constants of nickel:

Reflectivity..... = 65.5 per cent for $\lambda = 0.589\ \mu$
Absorption index (K)..... = 3.42 per cent for $\lambda = 0.589\ \mu$
Refractive index (n)..... = 1.58 per cent for $\lambda = 0.589\ \mu$

Elasticity

According to determinations of Harrison,[29] Grüneisen,[30] Schaefer,[31] Searle[32] and Guillaüme,[8] the value of Young's modulus for nickel varies from 21,000 to 23,000 kg. per sq.mm. (30,000,000 to 33,000,000 lb. per sq.in.)

Koch and Dannecker[33] and Harrison[29] have determined the values of the modulus of torsional elasticity and of Young's modulus, respectively, at higher temperatures; their values are given in Table IV.

Poisson's ratio for nickel is 0.33 according to Benton[34].

Hardness

In the annealed condition the scleroscope hardness of nickel of low carbon (0.10 per cent) and manganese (0.30 per cent) will vary from 9 to 12, using a universal hammer. The Brinell hardness under 3,000 kg. pressure determined on the same material varies from 80 to 100. The effect of carbon and manganese on the hardness of annealed metal will be discussed in a subsequent article under the effect of impurities on nickel. When hardened by cold working the scleroscope hardness may be raised to 40 to 45, the Brinell hardness to 250 to 350.

Tensile Properties

Table V gives the values usually obtained for the tensile properties of nickel of low carbon and manganese content in various conditions. These values refer to malleable A nickel of the International Nickel Co.

TABLE V. TENSILE PROPERTIES OF NICKEL

	Tensile Strength, Lb. per Sq.In.	Yield Point, Lb. per Sq.In.	Elongation in 2 In.	Reduction Area
Rolled and annealed malleable nickel	65,000 to 75,000	20,000 to 25,000	40–50	40–60
Hot rolled rods	68,000 to 78,000	21,000 to 26,000	40–50	40–60
Sheet, Hard rolled	120–130,000	110–120,000	5–10	20–40
Sheet, Annealed	65– 75,000	20– 25,000	40–50	40–60
Wire, Hard drawn	120–160,000	.....	.....	.....
Wire, Annealed	65– 75,000	.....	.....	.....
Cast nickel (deoxidized)	55,000	20,000	25	.....

TABLE VI. TENSILE STRENGTH AT HIGH TEMPERATURES

Temperature, Deg. C.	Tensile Strength	Yield Point
21	38,000	23,800
149	40,900	25,100
232	36,700	25,100
315	35,900	22,900
399	36,600	22,600
460	28,500	.....
482	27,800	14,200
499	31,900	.....
538	16,800	.....

Table VI gives the results of tests by Bregowsky and Spring[35] of the tensile properties at higher temperatures of nickel of unknown purity.

[1]Bureau. Standards, Circ. 35 (1915).
[2]Copaux, *Ann. chim. phys.*, vol. 6 (8), p. 508 (1905).
[3]Pecheux, *Lumiere elec.*, vol. 10, p. 232 (1910).
[4]Guertler and Tammann, *Z. anorg. allgem. Chem.*, vol. 52, p. 25 (1907).
[5]Wüst, F., "Die Temperature-wärmeinhalts Kurven der technischen wichtigen Mettalen." Forschungsarbeiten Gebiete Ingenieurswesens, No. 204 (1918).
[6]*Wiss. Abhands. Reichsantalt*, vol. 3, p. 269 (1900).
[7]*Z. physik. Chem.*, vol. 71, p. 257 (1910).
[8]*L'Eclairage Elec.*, vol. 16, p. 287 (1898).
[9]*Proc. Roy. Soc.* (London), vol. 65, p. 306 (1899).
[10]*Phil. Mag.*, vol. 7 (6), p. 626 (1904).
[11]*Ann. phys.*, vol. 4 (4), p. 104 (1901).
[12]*Trans Roy. Soc.* (London), vol. 208, p. 381 (1908).
[13]*Phys. Rev.*, vol. 33, p. 421 (1911).
[14]*Proc. Roy. Soc.* (London), vol. 66, p. 50 (1900).
[15]*Elec. Rev.*, vol. 48, p. 1014 (1901).
[16]*Ferrum*, vol. 10, p. 257 (1913).
[17]*Phys. Rev.*, vol. 30, pp. 268, 532 (1910).
[18]*Phil. Mag.*, vol. 3 (6), p. 177 (1902).
[19]*Physik. Z.*, vol. 11, p. 473 (1910).
[20]*Lumiere elec.*, vol. 7, p. 137 (1909).
[21]*Phil. Mag.*, vol. 40, p. 95 (1895).
[22]*Phys. Rev.*, vol. 9 (2), pp. 255, 394 (1917).
[23]"Magnetic Induction of Iron and Other Metals," D. Van Nostrand Co. *Trans. Roy. Soc.* (London), vol. 179A, p. 327 (1888).
[24]*Silliman's Am. Journal*, vol. 30 (3), p. 218 (1885).
[25]*Am. Chem. J.*, vol. 41, p. 208 (1909).
[26]*Z. Elektrochem.*, vol. 15, p. 607 (1909).
[27]*Z. Elektrochem.*, vol. 18, p. 568.
[28]*Ann. phys.*, vol. 31 (4), p. 1017 (1910).
[29]*Proc. Phys. Soc.* (London), vol. 27, p. 8 (1915).
[30]*Ann. Physik*, vol. 22, p. 801 (1907).
[31]*Drude's Ann.*, vol. 5, p. 220 (1901); vol. 9, pp. 665, 1124 (1902).
[32]*Phil. Mag.*, vol. 49 (5), p. 193 (1900).
[33]*Ann. Physik*, vol. 47, p. 197 (1915).
[34]*Phys. Rev.*, vol. 12, p. 36 (1901).
[35]*Proc.* Int'l Asso. Testing Materials, 1912, Sec. 1, VII.

Prevention of Sugar Deterioration

The phenomenon of raw sugar deterioration is described in Bulletin 175 of the Agricultural Experiment Station of the Louisiana State University, Baton Rouge. A summary of the findings is as follows:

By the use of superheated steam in centrifugals it was possible to reduce the number of micro-organisms over 90 per cent, thereby eliminating one of the most important factors in sugar and molasses deterioration. This method is simple, economical and efficient.

A survey was made of the deterioration of a large variety of Cuban raw sugars during normal storage. The results show that the number of micro-organisms together with moisture ratio (or factor of safety) is the determining factor in sugar deterioration.

It was possible to predict from the above data whether or not deterioration would take place, thereby preventing serious losses.

Mold spores contain an enzyme capable of forming gum in sucrose solutions of all concentrations up to the saturation point.

The gum formed is levan, as indicated by its physical and chemical properties, having a specific rotation of —40 deg. a melting point of 200 deg. C., and forming levulose on hydrolysis.

The Invertase method has been successfully applied in the determination of true sucrose in the presence of gum. The gum may be quantitatively determined polariscopically by combining the Clerget and Invertase methods.

Levan is formed from nascent levulose and dextrose (obtained by the inversion of sucrose). There is evidence that the former is used to a greater extent in gum formation. In the absence of sucrose and nascent reducing sugars, slight gum formation was obtained with c.p. reducing sugars. Levan is not formed directly from sucrose, but may be formed when the latter undergoes inversion.

Appreciable concentrations of acidity or alkalinity inhibit the activity of levanase, the optimum reaction being about P_H 7.0.

Estimating Impurities From Melting Point Curve

Walter P. White, of the Geophysical Laboratory, has discussed the limitations and described the experimental procedure for using the freezing curve of nearly pure substances for estimating the amount of impurity. The results are independent of the true melting point of the pure substance and even of the absolute accuracy of the thermometer or pyrometer. In checking purity by the capillary method it is customary to work until further purification produces no change. This condition, of course, may occur when by decomposition, solution of containers or absorption from air, an attempted purification causes no change in a substance already nearly pure. Such a large source of error, as well as a heavy wastage of time, is eliminated by the new method. (*J. Phys. Chem.*, vol. 24, p. 393; May, 1920).

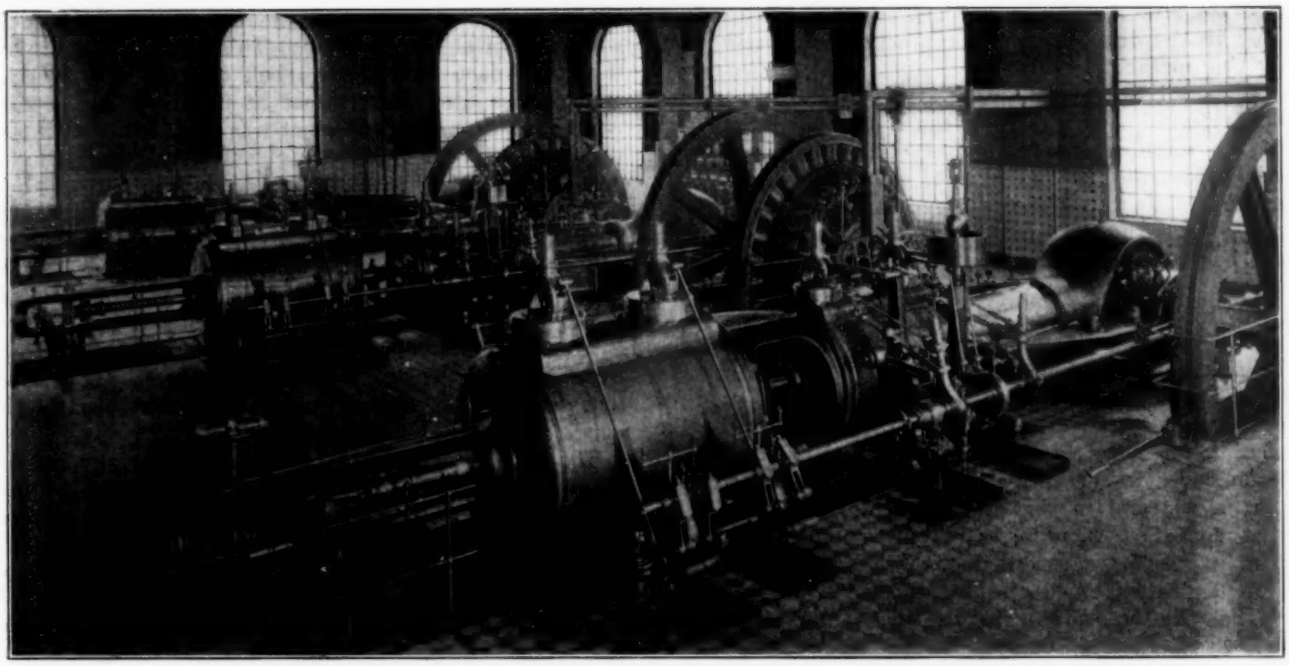

FIG. 1. GENERATING MACHINERY AT THE ELEKTROCHEMISCHE WERKE, BITTERFELD, GERMANY

Rise and Development of the Electrolytic Alkali and Chlorine Industry in Europe—I

An Outline of the Electrolytic Cells Employed in the Electrolytic Alkali and Chlorine Industry of the United Kingdom, Germany, Austria, France, Italy, Switzerland, Russia and Belgium

By JOHN B. C. KERSHAW

THE production, upon an industrial scale, of alkali and of free chlorine by the electrolysis of solutions of sodium or potassium chloride is now well established, for it is rather more than thirty years since the first successful installation of this kind was started by the Elektron Co., at Griesheim, near Frankfort, in Germany. Today electrolytic alkali works exist and are being operated in all the leading manufacturing countries where the raw materials of the industry are found; and even those who control the operation of the old Le Blanc process of alkali manufacture in the United Kingdom have found themselves at last compelled by the force of circumstances and by the changing conditions of the trade and industry to adopt the newer method of decomposing salt.

It must be remembered, however, that although Germany was the first country to operate an electrolytic alkali cell successfully upon a commercial scale, the early experimental and pioneer work in connection with this new branch of chemical industry was carried out in the United Kingdom.

An Englishman (Sir Humphry Davy) in 1807 first employed an electric current to decompose a fused salt, and in this way separated and discovered the metals potassium and sodium. Another Englishman (Michael Faraday) in 1833 discovered and formulated the laws that govern the action of an electric current in aqueous salt solutions and determined the electrochemical equivalent of various metals; and a third Englishman (Charles Watt) in 1851 applied for a patent which may be regarded as the master-patent of the electrolytic alkali and chlorine industry, since in this patent Watt described the conditions which must be observed in an electrolytic cell in which sodium or potassium chloride is being decomposed in order to obtain caustic hydrate, hypochlorite or chlorate.

Watt's patent (No. 13,755 of 1851) is of great historical interest; but at that date the dynamo had not been perfected, and as there was no practical means of obtaining large currents for electrochemical work, the electrolytic process of alkali and chlorine manufacture described by Watt remained dormant for another thirty-five years. Had Watt been able, however, to generate larger currents of electricity for his experimental work, he would have found that the production of alkali and chlorine in an electrolytic cell upon an industrial scale was not such a simple process as he had imagined, and that the choice of materials for and construction of durable anodes and diaphragms offered problems of considerable difficulty. The secondary reactions which occur in the cells between the chlorine ions liberated at the anode and the sodium or potassium

hydrate produced at the cathode also added considerably to the difficulties of manufacturing caustic alkali by this method.

Charles Watt in fact in his patent of 1851 recognized and referred to this possible cause of loss; but in spite of his warning, the inventors and exploiters of the Richardson and Holland type of cell failed to recognize or appreciate this difficulty; and it was owing to this defect that the first electrolytic alkali works built in the United Kingdom ended in a financial failure.

Classification of Cells

The cells now being operated industrially may be classified as diaphragm and non-diaphragm cells. In the former class a porous diaphragm, composed of cement, asbestos or other material unacted upon by the electrolyte (or by the ions produced by the electrolysis), is employed to separate the cell into two or more compartments; and in this way the chlorine liberated at the anode is to a large extent prevented from taking part in secondary reactions with the sodium or potassium hydrate formed at the cathode.

The "Elektron," Hargreaves-Bird, Outhenin-Chalandre, Basel, Billiter-Siemens, Nelson, Allen-Moore, Gibbs and Townsend cells are all of this type, the chief difference between them being in the construction or design of the diaphragm and in the arrangements made for withdrawing the sodium hydrate solution from the cathode compartment of the cell before it has had time to be decomposed by the electric current. The defects of all diaphragm cells are the higher voltage required per cell and the increased costs of maintenance due to the lack of durability on the part of the diaphragm.

For these reasons the other class—namely, non-diaphragm cells—have always attracted the electrochemist, and many of these have been patented and tried. Only two types have survived industrial trial—namely, (1) the Castner-Kellner, Whiting and Solvay cells, which employ a moving mercury electrode in the cathode compartment of the cell, and thus produce an amalgam of sodium which can be removed from the cell before it is decomposed by water with formation of sodium hydrate; and (2) the "bell" type of gravity cell, which makes use of the different specific gravities of the brine and of the newly-formed sodium or potassium hydrate solution in order to effect a separation of the two. The Aussig "bell" cell and the Billiter-Leykam cell are the only two representatives of this class in actual operation; the Richardson and Holland cell, which was tried on a large scale at St. Helens in 1896-1900, having proved a failure.

The attempts to use molten lead in place of the more expensive mercury in the liquid or moving electrode cells have also failed, after trial upon an industrial scale; the wear and tear of the cell structure and the fire dangers with this type of cell having caused the suspension of operation of the Hulin cell at Les Clavaux in France, and of the Acker cell at Niagara Falls, in America. The works where the latter cell and process were operated in fact was burned down and has not been rebuilt.

Electrolytic Alkali and Chlorine Industry in the United Kingdom

The first attempt to carry out the manufacture of caustic alkali and chlorine by electrolysis upon a large scale in the United Kingdom was made at St. Helens in 1895 by a company named the Electro Chemical Co., with a capital of $720,000. This company operated the Richardson and Holland bell type of gravity cell, and after a disastrous career of five years the works was closed down and the plant was sold in 1900 for the reasons already mentioned.

In the meantime the British Aluminum Co., of Oldbury, Birmingham, had been experimenting and developing the mercury cathode type of cell designed and patented by their chemist (H. Y. Castner) in 1892 and 1893; and in 1895-96 a company was formed and a works was planned for operation of what is now known as the Castner-Kellner process, at Weston Point, near Runcorn. This works started manufacture in 1897, and today is the largest and most successful electrolytic alkali works in the United Kingdom.

The Middlewich works, of what was originally the Electroyltic Alkali Co., was erected in 1899-1900, a very long interval having been allowed to elapse between the patenting of the Hargreaves-Bird type of diaphragm cell, in 1892-93, and its industrial development upon a large scale.

The last-named company and works have had a very checkered career, for at the end of 1910 they were forced into liquidation, and the plant, after lying idle for some time, was purchased for a comparatively small amount in 1914 by a new company (the Electro-Bleach & Byproducts Co.) and is again in operation.

In that same year the board of directors of the United Alkali Co., which controls the manufacture of alkali and bleaching powder by the Le Blanc process in the United Kingdom, decided to adopt and work an American type of electrolytic cell for the decomposition of brine and to gradually change over from the Le Blanc to the newer process. The outbreak of the war, however, delayed this change, and the large electrical generating station (the erection of which is now nearly completed) on the banks of the River Mersey, at Widnes, represents the first stage of this most interesting and striking development of the electrolytic process of alkali manufacture in the United Kingdom.

As the chairman of the company remarked at the annual meeting of the shareholders at which this change was announced, it was fortunate for the Allies that the change in the process of manufacture had not been made before the war broke out, since the large plants for sulphuric acid manufacture possessed by the United Alkali Co. were immediately placed at the disposal of the government in 1914 for the purpose of the war department, and the works at Widnes contributed a very large proportion of the concentrated sulphuric and nitric acids required for the production of high explosives during the period 1914-1918. Now that peace is once more restored, the delayed plans are being proceeded with, and it is expected that the first unit of the generating plant and of the connected installation of Gibbs cells will be in operation in the works of the United Alkali Co., at Widnes, before the end of this year.

The Castner-Kellner Cell and Process

The original Castner cell was constructed of slate, and was of comparatively small dimensions—namely, 72 in. long by 36 in. broad, and 6 in. deep. The cell is shown in sectional elevation in the diagram Fig. 2, and is seen to consist of three compartments, formed by two hanging slate partitions which dip into the

mercury lying on the floor of the cell. The solution of brine was fed into the two end compartments of the cell, which were completely closed and contained the anodes of graphite or carbon. The center compartment of the cell was open, and contained water. On passing an electric current of 1,300-1,400 amp. at 4½ volts through this cell, chlorine gas of exceptional

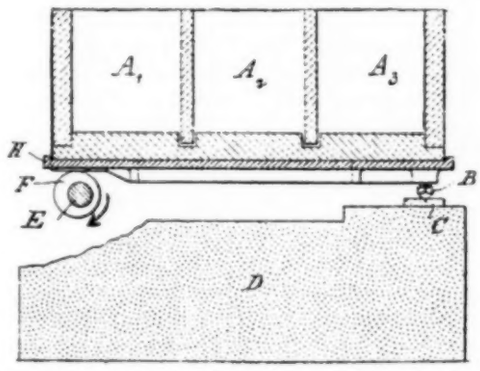

FIG. 2. THE CASTNER-KELLNER MERCURY CELL

purity, owing to the absence of OH anions, was liberated in the closed anode-chambers, and was conducted away; while the metallic sodium liberated at the surface of the mercury was at once absorbed by this and formed an amalgam. The cell was mounted with one end fixed and the other free, in such a manner that a slight but slow rocking movement could be given to the free end of the cell by means of an eccentric mounted upon a revolving-shaft which ran the whole length of the building in which the cells were placed; and the transfer of the sodium mercury amalgam from the anode-chambers of the cell to the central compartment, where it came into contact with water, was thus automatically effected.

The Kellner improvement of the Castner mercury cell consisted in making use of iron as the cathodic terminal of the cell in place of the mercury, a group of iron rods being so arranged in the central compartment of the cell that they were in electrical contact with the sodium mercury amalgam, and on treatment and decomposition of the amalgam by the water acted as the discharge point for the hydrogen gas. This improvement prevented the loss of mercury which had occurred due to the discharge of the hydrogen ions at its surface, and also reduced the emf. required to operate the cell, since the series $Hg.Na\text{-}H_2O\text{-}Fe_2$ produced a plus emf. The solution of sodium hydrate obtained in the central compartment of the cell was almost entirely free from chloride and could be concentrated to yield a very pure solid caustic without removal of the NaCl and other impurities by the usual "salting-out" process.

The original installation of the Castner-Kellner cells at Weston Point (Fig. 2) comprised 250 cells of the type just described, connected up in ten series of twenty-five cells each, the whole being supplied with electrical energy from 1,000-hp. steam-plant consisting of Willans and Robinson high-speed engines and Mather and Platt dynamos.

The works was quite successful from its start in 1897, and its record since that year has been one of continuous expansion of its manufacturing activity and of increasing profits for its shareholders. By 1905 the capacity of the plant had increased to 4,000 hp., and a change from steam to gas as source of electric power was inaugurated in that year by the erection of the first 800-hp. unit of a Mond gas plant, the original steam plant being scrapped as uneconomical and out of date.

The development of the manufacturing operations has proceeded even more rapidly during the last ten years. According to the latest official information, the works now (1920) has a total capacity of generating and decomposing plant of 25,000 kw. and the gas power plant, erected in 1907-1910, has been scrapped in its turn, in order to install a modern steam-turbine generating plant. In this new plant the boilers are of the Babcock & Wilcox marine type, having a steaming capacity of 34,000 lb. per hr., and generate steam at 200 lb. pressure for the turbo-generators.

The Solvay Cell

The mercury cell now used at this works, however, is of another form from the earlier type, since the

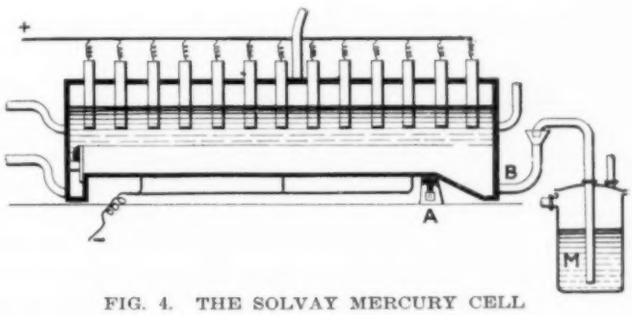

FIG. 4. THE SOLVAY MERCURY CELL

FIG. 3. CASTNER-KELLNER ALKALI WORKS. ORIGINAL CELL ROOM AT WESTON POINT

original Castner-Kellner cell described above was not adapted for operating upon a very large scale. According to Allmand, the cell now used is of the Solvay type, first employed at the Solvay works at Jemeppe in Belgium and worked there up to the outbreak of war. The cell (see Fig. 4) consists of a large slightly inclined rectangular cement trough, through which the mercury is circulated by means of an Archimedean screw. The brine flows through the trough from end to end in the same direction as the mercury, and carbon anodes are employed, terminating only 10 to 15 mm. above the surface of the mercury. The layer of the latter metal maintained on the floor of the cell is a very thin one, and the rate of movement is such that an amalgam of suitable concentration is obtained. This amalgam is decomposed in a separate vessel with the

aid of water, and the regenerated mercury is then returned to the electrolytic cell.

The cells at Weston Point take 4,000 amp. and make use of carbon in place of platinum as anode material. From 8 to 10 amp. of current is stated to pass per kg. of mercury employed in the whole cell.

The chief manufactures of this works during the war were pure alkali and liquid chlorine, the chlorine gas obtained from the mercury cell being exceptionally pure and therefore specially suitable for liquefaction. The manufacture of caustic potash of a very high degree of purity is another product; and metallic sodium is also

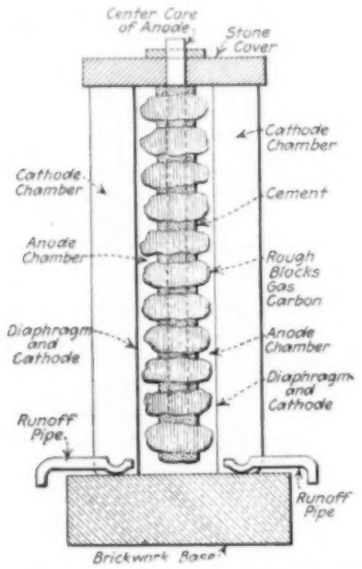

FIG. 5. VERTICAL SECTION OF HARGREAVES-BIRD CELL

manufactured by the electrolysis of fused caustic soda, according to the method patented by Castner in 1890.

The Hargreaves-Bird Cell and Process

The Hargreaves-Bird cell differs from the Castner-Kellner and Solvay cells in nearly every respect, for it is of the diaphragm type and contains liquid only in the closed central anode compartment or chamber. The construction of the cell may be best understood by reference to Fig. 5, which is a vertical cross-section of the cell, somewhat diagrammatic in form. The inner chamber contains the anodes, which are built up from blocks of gas-carbon; it is entirely closed, and is fed with a solution of common salt or (as at Middlewich) with natural brine from the salt-beds, after a preliminary treatment to remove impurities. It is closed on each side by a porous diaphragm, strengthened on its outer side by a screen of copper-gauze, which also functions as cathode of the cell. The two outer cathode chambers contain no liquid beyond the condensed steam and CO_2 gas, which is passed into these chambers and removes the soda as it forms upon the surface of the wire gauze cathodes. This solution trickles down the cathodes and is drawn off at the base; a solution containing from 10 to 16 per cent sodium carbonate is obtained.

It has been found more economical to produce carbonate of soda than caustic soda in this style of cell, since the union of carbonic acid gas with the sodium hydrate at the surface of the cathode produces a plus emf. and also assists in removing the sodium hydrate as it is formed from the action of the current. For this reason a mixture of steam and carbonic acid is blown into the cathode chamber of the cell; and these chambers, containing only steam and gas in place of any liquid electrolyte, are the distinctive feature of the Hargreaves-Bird cell. The cells were made of large dimensions, 5 ft. high, 10 ft. long and 14 in. wide, and decomposed about 224 lb. of sodium chloride per twenty-four hours. The current used was 2,000 amp. at 4½ volts.

As already stated, the first patents for the Hargreaves-Bird cell were taken out in 1892-93, and the cell received a very lengthy trial at Farnworth, near Widnes, before the Electrolytic Alkali Co. was formed, and a large works was erected at Middlewich, in Cheshire, in 1899.

The original installation comprised a steam-driven electrical generating plant of 2,000 hp. and eighty cells of the type described above. The anodes were built up from gas-carbon, by the method shown in Fig. 6. The cathodes were constructed, as already stated, of copper gauze, and were pressed tightly against the outer surface of the diaphragms, thus assisting to support these against the hydrostatic pressure of the liquid in the central (anode) compartment of the cell.

The construction of large and durable porous diaphragms, which could not be made too thick lest they should increase unduly the emf. required for working each cell, was one of the chief difficulties attending the operation of the Hargreaves-Bird process; the other was that carbonate of soda was not so profitable to manufacture as caustic soda. For these and other reasons the Electrolytic Alkali Co. was not able to earn adequate profits upon its capital, and as already stated it was obliged to cease manufacture and to go into liquidation about ten years ago.

The new company, entitled Electro-Bleach & By-

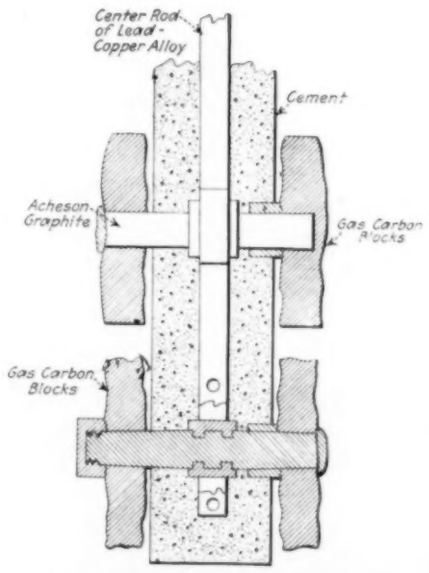

FIG. 6. ANODE OF HARGREAVES-BIRD CELL

products, Ltd., which purchased the plant in 1914 at a very low price and remodeled a large portion of it, still operates the Hargreaves-Bird cell and process at Middlewich in all essentials as described above. The cells, however, are now constructed of iron, lined with cement, and are built of 2,500 amp. capacity. The electrical generating machinery has been increased to

a capacity of 7,000 kw., and a change has been made from the use of high-pressure steam to low-pressure steam in certain of the processes, resulting in a very large economy. To enable the steam to be employed to the best advantage non-condensing reciprocating engines, direct-coupled to the generators, have been installed; while the additional power required is made up by condensing turbines. A further change made has been to increase the pressure of steam for the turbines from 150 to 210 lb., the steam being superheated to a temperature of 450 deg. F. The boiler-plant consists of seven large Babcock & Wilcox boilers, working at a pressure of 210 lb. and carrying a superheat of 150 deg. F. The plant within the power house consists of four reciprocating horizontal non-condensing steam engines driving direct-current generators, and three turbine sets, which by means of speed-reduction gearing drive also direct-current generators. The greater part of the current is employed for electrolytic work and is generated at the comparatively low emf. of 150 volts.

During the last five years, or since its inception, this company has been operating under the war conditions of inflated prices and has been able to earn very satisfactory profits for its shareholders. Whether it will be able to do so under the post-war conditions of trade and industry remains for the future to disclose.

Its products are bleaching powder, carbonate of soda, caustic soda, hyposulphite of soda and vacuum salt.

The managing director of the company in a recent letter stated that he has from time to time compared the results obtained by other types of cell with those obtained by the Hargreaves-Bird cell, and that he is satisfied that with the improved type of cell now employed the Hargreaves-Bird cell can easily hold its position.

The controlling interest in this company and in the Castner-Kellner Co. has now been obtained by Brunner, Mond & Co., which by an exchange of shares with the holders of the ordinary share capital in the two electrolytic alkali companies has secured the amalgamation of these two undertakings with its own larger firm.

The Gibbs Cell and Process

The Gibbs cell is of the vertical diaphragm type, and in this respect resembles the Hargreaves-Bird cell. The cell and diaphragm, however, are constructed of cylindrial form, in order to obtain greater strength in the diaphragm; and the cathode which surrounds the latter is constructed with a number of inward projections or points, which are imbedded in the diaphragm and thus reduce its electrical resistance.

Both faces of the diaphragm are submerged, and in this respect also the cell differs from the Hargreaves-Bird cell.

The construction of the cell will be understood from Fig. 7, which gives the sectional elevation and is reproduced from the English patent of 1907. The combination of diaphragm and cathode is seen in section at the points marked 8 and 9, the diaphragm being made thicker at the bottom than at the top, in order to contract the increasing rate of percolation of the brine from the anode chamber due to hydrostatic pressure. The diaphragm may be made of asbestos or any other suitable material which is permeable and is not attacked by the brine or by the products of the electrolysis. The cathode jacket may consist of a sheet of steel or other suitable metal, held in place by clamping bands or by other means.

The projections and indentations of the cathode plate which form the novel feature of the Gibbs cell are obtained either by simply punching holes through the annular sheet and then pressing it round the diaphragm with the rough edges on the inside or the sheet may be corrugated longitudinally and pressure be used again to force the projecting ridges of metal into the material of the diaphragm. According to the patent specification, the special advantages of this form of cathode

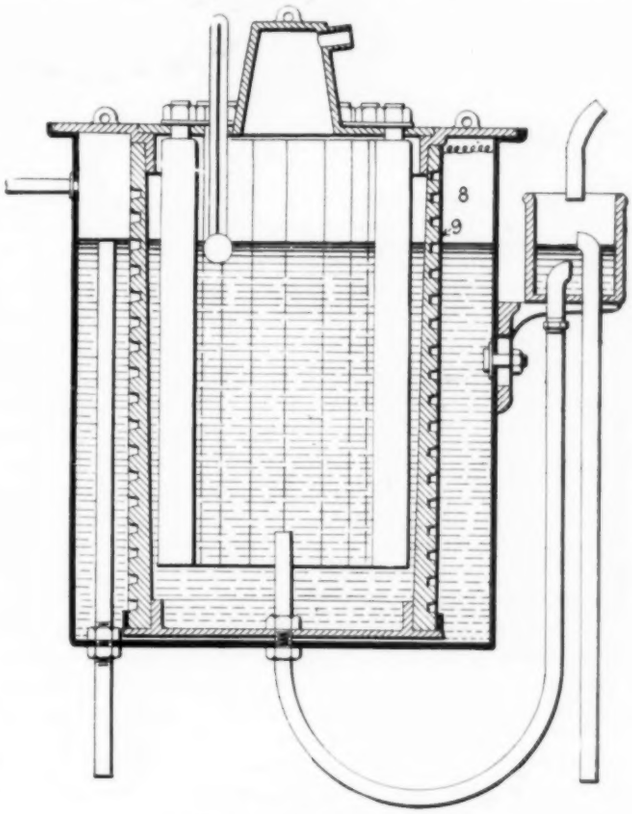

FIG. 7. THE GIBBS CELL

result particularly "from the same having points or projections entering the diaphragm" and also from the creation of "take-off" chambers or cups, which remove the caustic soda formed in their interior from the action of the current, and thus reduce the electrical losses due to the liberation of OH anions.

A further advantage claimed for this type of diaphragm is that the same permeability can be maintained for a very considerable time, whereas according to the patentee the permeability of the ordinary diaphragm decreases gradually, owing to clogging of its pores with the impurities of the electrolyte.

The following description of the action of the points on the cathode is taken from the patent specification:

> As the solution passes outwardly through the diaphragm where alkaline chlorides are treated, the caustic alkali will form upon the projections or points of the cathode. The bulk of the electrolysis takes place at these points or projections, and as the caustic alkali is formed, the flow of electrolyte carries it outwardly through the holes in the cathode and out of the region of electrolytic action. By thus carrying it away as it is formed, I avoid decomposing of the caustic alkali itself, and increase the efficiency of the cell.
>
> In the case of the cathode having the vertical passages, the liquid will flow either up or down along these passages and obtain the same result of carrying away

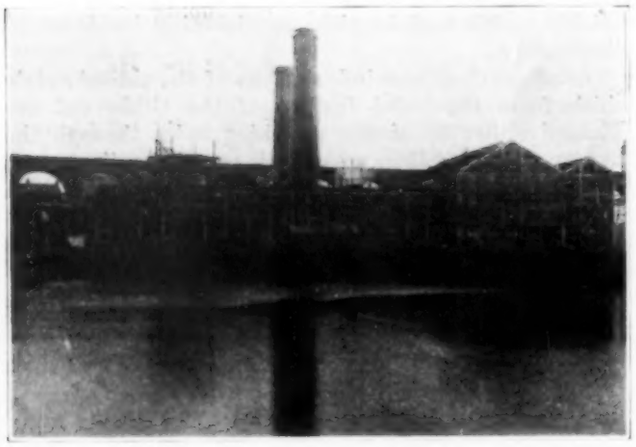

FIG. 8. UNITED ALKALI CO.'S PLANT AT WIDNES, UNDER CONSTRUCTION (EARLY IN 1920)

the products as they are formed. In both cases the electric current will flow mainly to the points or projections imbedded in the diaphragm, and there will be little or no electrolytic action in the troughs or portions more remote from the anodes.

The outer body of the cell is constructed of iron or any other suitable material, and the carbon anodes are securely fastened to the annular heavy flat ring which forms the top of the cell. This top can be removed, together with its attached carbon rods, in one operation by means of an overhead traveling crane when the cell is undergoing cleaning or repairs. The annular ring to which the diaphragm and cathode are attached can also be removed in a similar manner, and the rapidity and ease with which the cell can be dismantled is considered one of its good points.

No figures for its current or energy efficiency or for the strength and purity of the chlorine and caustic soda solution produced have yet been published; but the Gibbs cell had been used for some years in America by the Pennsylvania Salt Co., at Wyandotte, Mich.; and the United Alkali Co. before adopting it for its new installation at Widnes became convinced by exhaustive tests there and elsewhere that the claims made for it can be substantiated.

Proximity to Water Supply More Important Than Nearness to Fuel Supply

Fig. 8 shows the power station which is now under construction at Widnes for the supply of electrical energy to the new plant. The station is situated on the banks of the River Mersey, near the L. & N. W. Ry. bridge connecting Widnes and Runcorn. The site is convenient for fuel supplies and for disposal of ashes; and, being situated on the banks of the River Mersey, a full supply of cold water is always insured. Experience has shown that an abundant supply of condensing water is even more important than proximity to coal-supply, the transport of fuel being a much cheaper proposition than the transport of condensing water or the use of cooling towers. The station has therefore the great advantage of an ample supply of condensing water.

The boiler house will be equipped with eight Babcock & Wilcox boilers, provided with up-to-date mechanical coal and ash-handling plant.

(The second part of the article, dealing with the Electrolytic Alkali and Chlorine Industry in Germany and Austria, will be published in a subsequent issue.)

Industrial Possibilities of Chia Seed Oil

A new drying vegetable oil said to rival linseed oil is claimed to have been discovered and patented by Sebastian Lomanitz, of Bryan, Tex. He states that a plant chia, belonging to the genus *Salvia* and known as *Salvia hispanica* of the *Labiatae* family, yields a seed the oil of which has all the good properties of linseed oil, even the odor. The seeds of chia are used for the preparation of a beverage which is sold publicly in the streets of Mexico. There are a number of varieties of such seeds.

The chia plant is a shrub that reaches about 5 to 6 ft. in height and the seeds are oval shaped, about 1 mm. in the longest diameter and about ½ mm. in the shortest diameter. The yield per hectare varies between 4,000 and 1,000 kg. and in certain parts of the country two crops a year may be obtained. It is remarkable that in all classic books on vegetable oils, such as those by Lewkowitsch, Chershefsky, Beilstein and Abderhalden, there is no mention whatever that oil can be derived from this species.

Experiments performed with seven varieties of seed gave the following results: Average weight of 1,000 seeds, 1,166 g.; moisture, average, 7.33 per cent; oil average in seed, 32 per cent.

It will be noticed that the yield of oil from chia seeds exceeds the yield of oil from linseed. The test of oil obtained from seeds coming from different parts of the country gave the following data:

Sp.gr. 15.5/15.5	0.9341
F. F. A. (as oleic)	1.45
Index of refraction *nD* 40 deg. C.	1.4757
Index of refraction *nD* 17.5 deg. C.	1.48354
Reichert-Meisel number	0.1
Iodine value	187.59
Hehner value	94.16
Ester value	187.49

The oil remains fluid at low temperatures, similarly to linseed oil. The residue left after the extraction of the oil was found to contain substantially 30 per cent protein and could be utilized as a valuable cattle feed.

Particular attention is called to the specific gravity of the oil, to the index of refraction, the iodine value and the Reichert-Meisel value and also the fluidity at temperatures below normal, all indicating the close relation in drying qualities between this vegetable oil and that derived from linseed. The iodine value, which is the index of the drying qualities of the oil, is substantially that of the best linseed oils.

While it is possible to derive only 29 per cent of oil from linseed, it is possible to obtain about 33 per cent of oil from seeds of chia, the method of extraction being in no way more difficult than that of linseed oil. The great yield of oil from chia seeds and the value of the residue reduce considerably the price of the finished product. In view of the fact that two crops a year may be obtained, it is natural that the oil could be manufactured at a cost considerably lower than linseed oil.

Mr. Lomanitz has introduced this seed into Texas. growing it in Houston and Bryan on a small scale with a yield of about 20 bu. an acre. He harvested the crop by hand, picking out the spikes which contain the seeds and getting out the seeds from their tiny envelopes by rubbing them against a wire screen, sifting and blowing off the chaff.

The seed is very small and it is estimated that about 5 lb. would plant an acre.

American Association for the Advancement of Science, Chicago Meeting

Notes on Papers of Interest to Chemists Which Were Presented at Chicago — Phosphorescence, Fluorescence, Activated Sludge, Single Potentials, Crystalloid Filters, Ionization and Resonance Potentials, and the Theory of Chemical Reactions

CHICAGO UNIVERSITY entertained the annual meeting of the American Association for the Advancement of Science during Christmas week with representatives from sixteen branches of science ranging from mathematics, physics and chemistry to geology, medicine and education.

General Sessions

Robert W. Wood gave a lecture Wednesday night on "High-Power Phosphorescence and Fluorescence," in which he defined a phosphorescent body as one which when subjected to light rays, or perhaps to ultra-violet invisible rays, itself becomes luminous and continues to emit light after the excitation has been removed. It is possible that all solids have this property, but if so most of them have periods of self-luminosity following excitation so short that they cannot be detected by present methods. A high-power apparatus has been devised which generates ultra-violet rays of singlar intensity, yet invisible to the ordinary eye. They have been used for the purpose of naval signaling, in particular for finding invisible running lights for convoys. The rays are detected at the receiving point by means of a wide angle telescope with a screen which phosphoresces under the influence of the ultra-violet rays from the signaling apparatus. A similar device is of use in cancer hospitals for diagnosing pathological condition in tissues by phosphorescence.

Two lamps were exhibited which made the entire audience and auditorium phosphorescent. Faces became self-luminous with a gray tint, teeth with bright blue, while artificial teeth remained an inky black. Different dress materials phosphoresced with different colors corresponding to the properties of their various dyes, the lenses of the eyes became themselves phosphorescent, emanating rays of a light blue or lavender color.

A fluorescent body is one which receives light rays of one type and, as a result of the excitation so produced, re-emits light of a different character. There are, for example, substances which when illuminated by red light give out again rays which are green. Some varieties of red ink show this property slightly. Prof. Wood has demonstrated that fluorescence of this character is always accompanied by a chemical decomposition of some sort in the fluorescent substance. A particular example is rhodamine, which when first illuminated with blue light produces orange red. Later it gives green, and at a first stage in its chemical transformation it becomes non-fluorescent.

Chemistry Section

Some Properties of Activated Sludge, by A. M. Buswell and C. C. Larson.—It is known from published analyses that the quantity of nitrogen in septic tank contents varies from 1 to 3 per cent, in intermittent filter contents from 1 to 4.5 per cent, while activated sludge has from 4.5 to 6.5 per cent nitrogen content, making it useful as a fertilizer. This activated sludge is in general produced by blowing air through the sewage, causing the milkiness to disappear and the sludge to flocculate. If the material is not handled quickly, it soon decomposes again to a putrescent mass which cannot be used. It is filtered or centrifuged to remove 85 per cent of the water and then dried by heat. Acidification is beneficial to the filtering process, as it tends to cause the solids to contract. Acid also prevents the material from becoming septic and so allows slow separation by gravity. One-third of the amount of acid determined by titration with methyl orange indicator is actually necessary, for it has been found that the action depends on the intensity or H-ion concentration rather than the capacity factor.

On the Single Potentials of Arsenic and Its Position in the Electrochemical Series of Metals, by Louis Kahlenberg and Vernon Steinle.—The electrodes used were solid arsenic, arsenic plated on gold and platinum and the arsenic mirror from AsH_3 plated on a glass tube. Powdered arsenic was pressed to a bar and coated with paraffine. Finely divided metal was imbedded in gelatine or cellulose acetate. The single potentials secured were as follows:

With sawed piece of arsenic	—0.554 volts
and	—0.553 volts
With paraffine coated piece	—0.549 volts
With arsenic mirror	—0.552 volts
With pressed stick of arsenic	—0.548 volts
With powder in gelatine	—0.544 volts
With powder and cellulose acetate on platinum	—0.551 volts
On gold	—0.554 volts

Membranes for Separating Crystalloids From One Another, by Louis Kahlenberg.—There is no record in the literature where crystalloids in aqueous solution are separable by a membrane. The author found that a membrane prepared from thin china silk dipped in melted lanoline, the fat from sheep's wool, will separate sugar from salt or potassium iodide in aqueous solution.

An Attempt to Activate Chlorine Photometrically, by Gerald L. Wendt.—In line with the research work carried out by the author where he successfully prepared activated or ozone forms of nitrogen and hydrogen by the brush electric discharge, he has unsuccessfully attempted the same with chlorine, using mercury electrodes. The next step was to set up an apparatus consisting essentially of an ultra-violet light in a central glass tube surrounded by a second glass tube to form an annular space through which dry chlorine was passed and subsequently conducted into the dark, where it was mixed through a three-way cock with hydrogen. Tests of the mixed gases showed that no HCl was found. In other words the chlorine was not activated. The two

gases were inert compared to Draper's experiments where rapid combination is secured by exposing the mixture to light.

Physics Section

The American Physical Society co-operated in presenting some valuable papers having a bearing on chemical topics.

The work done by such physicists as Dr. Foote and Dr. Mohler of the Bureau of Standards in determining the "Ionization and Resonance Potential" of various chemical elements and compounds is going to be very valuable to the chemist in obtaining a more intimate insight into the mechanism of activation which precedes all chemical reactions. Most chemical reactions, especially those involving carbon compounds, are not accompanied by actual ionization, so that the resonance potentials are apt to be more valuable from our standpoint. When the electron hits a molecule in such a way that its energy is absorbed, probably by the displacement of a valence electron, and the absorption is measured, the quantity is known as its resonance potential. This corresponds to a state of activation which may result in chemical action. Thus zinc ethyl has a resonance potential of 7 volts and an ionization potential of 12 volts. Carbon monoxide has a whole series of resonance potentials indicating several degrees of activation.

From the chemical standpoint this means that during the first stage it might react with chlorine or ozone. During a second stage it might react with the more active oxygen molecules and when at some of the higher stages it might react with some form of hydrogen to form formaldehyde. At all events something of the sort does take place in the leaves of plants, carbon dioxide being reduced and combined with hydrogen to form formaldehyde. This suggests a possible artificial synthesis of carbohydrates.

Another interesting thing noted by these gentlemen was that the vapors of sodium or potassium chloride at 2 mm. pressure are highly ionized, while metallic calcium vapor is not ionized. Does this mean that these salts are ionized at the same time that evaporation occurs? According to Langmuir they are already ionized in the solid crystal, and on evaporation, while there is a tendency to form pairs, there is also a tendency for some of the ions to stay apart as they do in solutions. In the calcium vapor there is nothing to remove the electrons from the metallic nucleus as there is in the salts where chlorine has a far greater attraction for the valence electron than has the metallic nucleus.

Dr. Davey, of the General Electric Co. Research Laboratory showed how X-ray crystal analysis confirmed Langmuir's postulates as to atomic structure. Langmuir has shown how the Cl^- ion and the K^+ ion have the same outer shape as the argon atom, so that all are isoteric. As each of these has eight electrons in the outer shell, they should be cubical. As a matter of fact all crystals of all the alkali halides are cubical. In a similar manner the alkaline earth oxides and sulphides are usually cubical. The iron atom having eight electrons in its outer shell is cubical. Then the Ni^{++} ion should have the same shape, making NiO a real cube, as it is. The Tl^+ ion and Pb^{++} ion lack six electrons of completing the stable arrangement corresponding to the inert gas, niton, so that they should have a cubical shape with rounded corners. This results in the formation of cubical crystals of TlCl and PbS.

A. J. Dempster of Chicago University, using the apparatus described in *Physical Review*, April, 1918, has shown that magnesium consists of isotopes of atomic weight 24, 25 and 26 as referred to nitrogen of molecular weight of 28.

An entirely new method for the determination of isotopes has been developed by F. W. Loomis of New York University. By observing the infra-red absorption spectra of various gases with a high degree of dispersion he has shown that bands due to hydrogen chloride contain two peaks corresponding to chlorine of atomic weights 35 and 37. Fluorine and bromine do not show any isotopy by this method.

Dr. Farrington Daniels of the University of Wisconsin gave a very able summary of the present status of the radiation hypothesis of chemical reactions which is receiving attention in this country from men like Langmuir and Tolman [*J. Am. Soc.*, vol. 42, pp. 2190, 2506 (1920)]. The first part of his discussion was presented at the Chicago meeting of the American Chemical Society [CHEM. & MET., vol. 23, p. 563 (1920)]. Daniels has shown that the decomposition of nitrogen pentoxide is monomolecular in gaseous condition and also when dissolved in carbon tetrachloride even at 15 atmospheres pressure. He has calculated the heat necessary for activation and compared it with the total black body radiation at temperatures from 20 to 100 deg. C. At the higher temperature there is not enough radiant energy to produce the actual activation observed. These facts are unfavorable to the radiation hypothesis.

Other Sections

Among the excellent papers given at other sectional meetings was one presented by Frank B. Dains of the University of Kansas before the section of Historical and Philological Sciences entitled "Applied Chemistry in Prehistoric and Classical Times." Chemical information was current in considerable amount about 2,000 years ago, but remained without much development until the time of Paracelsus, 1,400 years later. Chemistry is said to begin when copper and tin were mixed together in certain proportions by weight to make bronze, but really began when ores were first smelted to produce metals, or even before, when fire was discovered—or perhaps when man or animal first breathed, or perhaps, in Biblical terms, In the beginning, when God created the universe. Investigations in the valley of the Nile revealed a complete plant equipped with crushers, concentrating tables and cupels for producing metallic gold. Mercury was derived from artificial HgS about 1000 B.C.

Iron was probably first produced in Asia Minor. The Romans had blast furnaces similar in shape to the present-day furnaces but the metal was not completely melted. The mass was alternately heated and hammered to produce the crude metal.

Zinc and tin were made about the time of Paracelsus. Lead was used in Rome for piping water, for coffins and for household utensils. Copper and antimony were known in antiquity, as were red and yellow sulphides of arsenic. The historical development of the Mediterranean nations was in direct proportion to the development of their technical arts.

While it is well to study the literature for the history of chemistry, even more may be gleaned by making analyses of ancient products. Such work reveals the ancients' knowledge of indigo and alizarin dyes. Analyses of ancient glasses and ceramic ware may throw new light on their work. Historical research, then, should look to the analytic methods.

British Chemical Industry

(FROM OUR LONDON CORRESPONDENT)

London, Dec. 13, 1920.

THE chemical trade is, as usual at this time of the year, inclined to be slow, but the slackness has been accentuated by the adverse conditions prevailing in the cotton, paper, leather and other trades. Heavy chemicals are maintaining their price well in spite of foreign competition and in most cases are still far above the actual cost of manufacture.

DYESTUFFS BILL APPROVED BY PARLIAMENT

The dominant feature of the past month has been the dyestuffs campaign, culminating in a partly agreed bill which, like nearly all British safeguards and expedients, will, it is hoped, save the industry literally at the eleventh hour. Under the terms of the bill the importation, subject to a system of licenses, of all synthetic organic dyestuffs and colors and of intermediates used in their manufacture is forbidden for a period of ten years. The Board of Trade is the licensing authority and is to act under the guidance of an advisory committee comprising five users, three manufacturers and three members of the public. The merchant is apparently left out in the cold, but will derive comfort from the fact that the act does not apply to goods for reexport.

Apart from the natural doubts and misgivings with which this last-minute compromise has been received by the cotton trade and other users, many important sections of the chemical industry are greatly troubled in regard to the possibility of a very wide interpretation of the term "organic intermediate products." Some of the products which may fall within this category may have only a restricted use for dyestuffs and the like as compared with their consumption in the chemical and allied industries as a whole. The infant fine chemical trade in particular, which in the past manufactured completely only a small proportion of the goods sold, seems to be particularly affected and efforts are again being made—probably too late—to put this industry also on an economically satisfactory basis.

BRITISH CELLULOSE CO.'S $1,000,000 DEFICIT

As foreshadowed in these notes of September and October last, the facts and figures presented at the second annual meeting of the British Cellulose Co. held last month are not encouraging. The change over from war to peace conditions has proved a very slow business and for its future prosperity the company seems to rely mainly upon the success of its artificial silk processes. The deficit is quite comprehensible in view of the fact that production has hardly commenced, but even now there seems no prospect of achieving the production originally promised, although the chairman stated that with a one-ton-per-day plant in commercial operation the loss in trading would cease. The problem of dyeing cellulose acetate silk satisfactorily under all circumstances does not yet appear to have been solved, but this is perhaps only a matter of time and experience. Meanwhile much stress is laid upon its special insulating properties, which are stated to be several times greater than those of natural silk. The general feeling seems to be that the cellulose acetate industry will ultimately be firmly established, but meanwhile the enormous value—about $7,000,000—placed upon good will and patents is having a deterrent effect upon the average investor and it certainly seems difficult to justify.

FAILURE OF INJUNCTION AGAINST BRUNNER, MOND

It will be remembered that the proposal of the directors of Brunner, Mond & Co., Ltd., to devote $400,000 in aid of research was negatived at the annual meeting by a show of hands, but it was subsequently confirmed at a special meeting called for that purpose. A shareholder endeavored by process of law to oppose this decision on the ground that the directors had exceeded the powers conferred upon them by the articles of association of the company. Most of the large companies and corporations in this country have realized that money spent on scientific research and for the benefit of the chemical industry generally may be relied upon to pay good dividends and an adverse decision would have been most unfortunate. Moreover, the appeal for $2,000,000, which is now to be launched for the establishment of a central home for the leading chemical societies and for an ambitious scheme of chemical publications was obviously dependent in some measure upon the support and generosity of the large chemical firms. It remains to be seen whether the legality of a donation to such purposes will also be called into question.

WAVE POWER TRANSMISSION

This novel form of transmission of energy was mentioned in a recent note (see CHEM. & MET. ENG., Nov. 10, 1920, p. 913). The details of this invention are difficult to describe in a short note and possibly the following supplementary particulars may therefore be welcome. If we imagine two cylinders fitted with plungers and connected together by a long pipe completely filled with water, this represents the simplest form of wave transmission. If one of the plungers is now moved rapidly up and down, it will set up at each downward stroke harmonic waves of compressed water, which, traveling along the pipe at high speed, will exert their energy on the plunger at the far end and if there is a suitable resistance to the movement of that plunger, a simple synchronous reciprocating motion will be produced. The two cylinders in their developed form are the wave generator and wave motor respectively of the previous note on this subject, but of course the actual development of this harmonic series of impulses into actual practical use is a more complicated matter than the above statement. The main underlying principle involved is really the fact that water is compressible. If a piston is forced under pressure into a pipe 1 in. in diameter and 500 ft. long by about $\frac{1}{4}$ in. in thickness, closed at the far end, the decrease in the volume of the water due to its being compressed is about seventeen times as great as the increase in volume due to the expansion of the pipe line under pressure. The net result is that the piston would enter the containing pipe for a distance of about 11 in. The resulting power wave when this principle is applied in suitable machinery enables practical use to be made of this harmonic motion, which offers an excellent analogy in many ways to alternating current practice in that their laws, formulas and conceptions are very nearly interchangeable. Readers who are more closely interested should write to W. H. Dorman & Co., Ltd., Stafford, England, who would no doubt be glad to give them full particulars.

Current Events
in the Chemical and Metallurgical Industries

Tariff Commission's Surveys of the Chemical Industries

When the Ways and Means Committee held its hearings on chemicals Jan. 6, 7 and 8 in Washington it had at its disposal comprehensive information regarding the complicated and extremely technical tariff problems of the chemical industry. This information was prepared by the United States Tariff Commission in the form of reports known as "Tariff Information Surveys," each of which presents, without suggestion of tariff policy or rates of duty, the main facts and figures pertinent to tariff legislation.

In general the survey follows a standardized form, consisting of a description of the article; uses to which it is put; methods and processes of its manufacture; notable divergences between American and foreign methods of production; the nature and source of its raw materials, and statistical data concerning domestic poduction, imports and exports, prices, and costs of production, as far as are obtainable, in the United States and in foreign countries.

Schedule A of the tariff act—chemicals, oils and paints—consists of seventy paragraphs, many of which contain provisions for several different products. In some cases the Tariff Commission prepared a single survey to cover a whole paragraph in the tariff act; in other cases, where a paragraph enumerates several unrelated articles, a separate survey was prepared for each article.

The hundred or more surveys of the chemical industry have been grouped into nineteen pamphlets, each of which has been published by the Ways and Means Committee of the House of Representatives, from whom they can be obtained on request.

1. "Acids of Paragraph 1 and Related Materials," includes surveys dealing with boric, citric, formic, gallic, lactic, oxalic, pyrogallic, tannic and tartaric acids, and all other acids and acid anhydrides not specially provided for in that section.

2. "The Wood Chemical Industry," includes surveys dealing with acetic anhydride, acetone, formaldehyde, acetic acid, wood alcohol, calcium acetate, charcoal, and tar and pitch from wood.

3. Paragraphs 4 to 9 inclusive. This includes aluminum and ammonium compounds, egg albumen, copaiba, Peru, tolu and other balsams, as well as the general provision in paragraph 5 for "all chemical and medicinal compounds, preparations, mixtures and salts, and combinations thereof not specially provided for in this section."

4. "Barytes, Barium Chemicals, and Lithopone," includes all of the barium salts in paragraph 10, crude barytes, ground barytes and blanc-fixe in paragraph 51, and lithopone in paragraph 60.

5. Paragraphs 11 to 17 inclusive. This includes blacking of all kinds, bleaching powder, caffeine and tea waste, mercurial preparations, chalk, and chemical and medicinal compounds containing alcohol or imported in capsules, pills, ampoules, etc. Liquid chlorine, whiting and paris white are also discussed in this pamphlet.

6. Paragraphs 18 to 26 inclusive. This includes chloral hydrate, salol, phenolphthalein, aspirin, thymol and other medicinals, chloroform, carbon tetrachloride, cobalt oxide, collodion and pyroxylin plastics, and coloring for brandy, wine, etc. Sulphur chloride is also discussed in connection with the surveys of chloroform and carbon tetrachloride.

7. "Botanical Drugs." This consists of a general survey of the crude botanical drug industry, whose products are dutiable under paragraph 27 or free under paragraph 477, and in addition there have been included the surveys of ergot, paragraph 28, and of the ethers and esters dutiable under paragraph 29.

8. "Tanning Materials and Natural Dyes." This includes all natural tanning materials and vegetable dyes, such as sumac, logwood and other dyewood extracts, chlorophyll and saffron of paragraphs 30 and 31. The following paragraphs from the free list are also discussed in this connection: 399, 455, 469, 475, 492, 536, 538, 553, 564, 618, 624, 630, 634 and 639.

9. Paragraphs 32 to 38 inclusive. This includes surveys of fusel oil, butyl alcohol, gelatine and glue, glycerine, camphor, gum arabic, dextrine and other gums, inks and ink powders, iodine, iodoform and potassium iodide.

10. Paragraphs 39 to 43 inclusive. This includes surveys of buchu leaves, coca leaves, gentian, licorice and sarsaparilla roots, magnesia and magnesium compounds, and menthol.

11. "Animal and Vegetable Oils." This includes all of the fish and animal oils of paragraph 44 and the expressed vegetable oils of paragraph 45. In addition the following oils, free of duty under paragraph 561, are discussed: Chinese nut oil, coconut oil, cod and cod liver oil, cottonseed oil, palm and palm kernel oil, perilla and soya bean oil.

12. "Essential and Distilled Oils." This includes surveys of all essential oils enumerated in paragraph 46, and, in addition, the following essential oils from the free list: Cajeput, ichthyol and juglandium.

13. "Opium." This includes the surveys of opium, cocaine and related alkaloids.

14. "Perfumery, Cosmetics and Toilet Preparations." This includes perfumery, cosmetics and toilet preparations under paragraph 48, and the natural and synthetic perfume materials under paragraph 49; also healing and court plasters under paragraph 50.

15. "Paints and Pigments." This includes all of the surveys dealing with paints and pigments in paragraphs 51 to 63 inclusive, with the exception of barytes, blanc-fixe and lithopone, which have been discussed under paragraph 10.

16. "Potassium Compounds." This includes the surveys of potash and the potassium salts, dutiable under paragraph 64, or free of duty under paragraph 580.

17. Paragraphs 65 to 66. This includes the surveys of salts and compounds of bismuth, gold, platinum, silver, tin, etc.; also the surveys of soaps, dutiable under paragraph 66.

18. "Sodium Compounds." This includes all the sodium salts, dutiable under paragraph 67 or free of duty under paragraph 605; also potassium prussiates, potassium nitrate, potassium chromate and bichromate, dutiable under paragraph 64; chromic acid and silicic acid, free of duty under paragraph 387; chromium hydroxide, paragraph 449; calcium nitrate, paragraph 440; potassium nitrate, crude, and potassium cyanide under paragraph 580.

19. Paragraphs 68 to 70, inclusive. This includes surveys of sponges, talc and soapstone, vanillin, vanilla and tonka beans.

American Engineering Council Assumes Activities of Former Engineering Council

On Jan. 1, 1921, American Engineering Council of the Federated American Engineering Societies assumed the continuation of such activities as have been conducted for the past three and one-half years by Engineering Council of the United Engineering Society. This transfer of activities was made effective by the action of Engineering Council on Dec. 16 in recommending to United Engineering Society that Engineering Council be discontinued. Subsequently United Engineering Society amended its bylaws so as to disestablish Engineering Council.

Symposiums on Drying and Filtration Planned

For the Rochester meeting of the American Chemical Society the division of industrial and engineering chemistry plans to have a symposium on drying. Plans for the program are in charge of the committee now being formed under the chairmanship of Charles O. Lavett of the Buffalo Foundry & Machine Company of Buffalo, N. Y. Those interested in this symposium should communicate their suggestions to the chairman of the committee.

On the occasion of the fall meeting, in New York City, the industrial division program will include a similar symposium on the subject of filtration. The chairman and committee in charge of this program have not yet been selected, but further arrangements will probably be perfected in the near future, as the secretary of the division, Dr. H. E. Howe of the National Research Council, has the matter actively in charge at present.

International Chamber Committee Organized

The American committee to represent in this country the International Chamber of Commerce has fully organized and held its first meeting in New York City on Jan. 6. This agency is the direct representative and point of contact in the United States with the International Chamber of Commerce, which has its headquarters in Paris. Chemical, metallurgical and other engineering interests are represented on the board by the following gentlemen, among others: Herbert C. Hoover, representing Federated American Engineering Societies; Thomas S. Grasselli, Grasselli Chemical Co.; E. A. S. Clark, Consolidated Steel Corporation; A. C. Bedford, Standard Oil Co.; C. F. Kelley, Anaconda Copper Mining Co.; E. G. Miner, Pfaudler Co.; William H. Nichols, General Chemical Co.; Thomas A. O'Donnell, American Petroleum Institute; John J. Raskob, Dupont Co.; Charles M. Schwab, Bethlehem Steel Corporation; Charles A. Stone, American International Corporation; E. P. Thomas, U. S. Steel Products Co.

Nitrate Plant Controversy Grips Senate and House

The nitrate plants at Muscle Shoals, the proposed United States Fixed Nitrogen Corporation and the Wilson dam have come in for extended discussion in Congress during the past two weeks. The Nitrogen Corporation bill became the unfinished business in the Senate after Senator Underwood, the Democratic leader, had threatened to delay the Republican legislative program unless the bill were taken up. In the House the nitrate plant controversy was precipitated by the failure of the Appropriations Committee to provide funds for the continuation of the work on the Wilson dam.

Division of opinion on the matter, however, was not along party lines. The Democrats are not a unit for it, nor are the Republicans uniformly against it. In fact, Representative Mann, of Illinois, one of the Republican leaders, proved to be an effective champion in favor of continuing the work. Opinion in the House is evenly divided, as is indicated by the close vote on the first test of strength, when 125 votes were cast to override the committee, against 132 in support of the committee's position.

An unexpected development in the Nitrogen Corporation discussion came when Senator Wadsworth, of New York, submitted amendments withdrawing the corporation entirely from the jurisdiction of the War Department and proposing that it be placed under the Treasury Department, because he believes "soldiers ought not to be running a business concern." Another amendment by Senator Wadsworth proposes material changes in the plan for capitalization. He would give the corporation the power to sell common stock in any amount not to exceed $20,000,000. Another amendment by Senator Wadsworth limits the activities of the corporation to the manufacture of ammonium nitrate, ammonium sulphate and cyanamide from atmospheric nitrogen.

In submitting his estimates to Congress the Secretary of War requested $10,000,000 for the continuation of the work on the Wilson dam. This item was entirely omitted by the committee in framing the sundry civil bill on the ground that the policy with respect to carrying forward the project had not been worked out.

In the course of his remarks Mr. Good, chairman of the Committee on Appropriations, said: "I can but feel that a great blunder was made when the American Cyanamid Co. was given a free hand in the making of the plans for building Plant No. 2, which is the large plant. I have forgotten whether it is the American Cyanamid Co. or the American Chemical Co., but the two were in very close relation. One of them prepared the plans and constructed this plant. One or the other of these companies, which have been working very closely together, has the patent rights for the Haber process. The Haber process is covered by a great many letters patent and these companies, or one of them, hold the letters patent. True, the basic patent was granted seventeen years ago, but when this company was given the power to make the plans for this plant it made its plans for the manufacturing plant to fit in with its patents. So every unit of the building, every piece of construction, everything that was done was in order to turn out nitrates at Plant No. 2 under the Haber process, which is covered by these patents, and the company receives royalties on every ton produced—$5 a ton royalty on cyanamide and $10.11 a ton on nitrates of ammonia. The royalties under the present contract for 100,000 tons of nitrates of ammonia, the estimated annual production, would be $2,200,000."

At another point in his remarks Mr. Good said: "We will have to become accustomed to some higher Government salaries if the Government is going to engage in this kind of enterprise. You cannot compete with the American Cyanamid Co. in the manufacture of fertilizer and nitrate if you are going to have $2,500-a-year men or $5,000-a-year men to manage the plant when a competing company pays from five to ten times such sums for their managers in order to secure the best talent available. You must apply to Government affairs the same business principles that a business man adopts in connection with his affairs if you want the Government to succeed in business."

Among the champions for the continuance of the project was Representative Garrett, of Tennessee. At one point in his address he stated that some chemists are of the opinion that eventually the Haber process will be developed to a point when nitrates can be fixed at a cheaper cost by that method than by the cyanamide process, but he continued: "We must bear in mind that however hopeful gentlemen may be of the eventual development of the Haber process it still is speculative in this country and the cost of production by it necessarily is speculative."

At another point in his remarks Mr. Garrett expressed the opinion that it is not possible to dispose

of the nitrate plant to private parties at any price that would approach, even remotely, a just return to the Government. "So far as I know," he continued, "no one ever has believed that it is possible for private capital to construct this dam economically."

Representative Graham, of Illinois, deprecated the spirit of "let the Government do it." So far as the nitrate plant controversy is concerned, he said, the parting of the ways has been reached. "We must either embark on the national management and manufacture of fertilizers or we must take the other road which leads to individual initiative and enterprise." He expressed the opinion that the real purpose of the power development is to erect at Muscle Shoals, at Government expense, a water-power project for the development of that part of the country. "I am opposed to junking this plant," he declared. "I am equally opposed to the Government running it, if there is any other way to do it. I favor its operation by private capital. Plant No. 1 is a failure, always has been a failure and always will be a failure. At the time it was built they knew considerable about the Haber process, which, by the way, is the coming process in this country. The method to be used in Plant No. 2 is obsolescent. Inside of ten years it probably will not be used at all. The Haber process is a simpler process. It has grown by leaps and bounds during the war. The Haber patents are open to the use of any man. I am informed privately that there are at present organizations in the United States, with great capital behind them, organized for the manufacture of synthetic ammonia by the Haber process. If the United States goes into the business that industry perishes, as do all others related to the production of nitrates from the atmosphere. How can any privately owned industry compete with the United States Government?"

Representative Almon, of Alabama, said: "Who is opposing the proposition that the Government should operate this plant? No one has come out in the open in opposition except Mr. Washburn, who operates a similar, but much smaller, plant at Niagara Falls, on the Canadian side. This plant would be his competitor."

Representative Mann, in concluding his speech, said: "Shall we scrap a plant simply because we feel resentment at its cost? Shall we throw away an opportunity because we do not like the men who have created it? Shall we waste the thing that we have because we do not like the methods that have been followed? We ought to rise above that. We ought to be willing to continue the work which is of benefit to the country and which utilizes Nature's power to draw from the air this plant food."

National Public Works Association Final Report

The final report of the National Public Works Association has just been completed by C. T. Chenery, secretary, dated Dec. 30. American Engineering Council will take over the work of this association, together with the work of Engineering Council, the first of the calendar year. This report of the public works activities is, therefore, its final summary of association affairs.

In addition to the effort to obtain passage of a bill to create a department of public works, known as the Jones-Reavis measure, this association has been active in support of the resolution recently passed by Congress known as the Smoot-Reavis resolution, providing a Congressional commission for the investigation of the need of and basis for reorganization of the executive departments. In fact, the Public Works Association can properly be credited with having been one of the most influential agencies in obtaining the early passage of this resolution, which has just become a law through the failure of the President to act on the measure within ten days following its submission to him, which ten days expired December 30. It is hoped by those interested in the public works department that the need for it will be quickly demonstrated and that the first measure approved by the commission will be this particular part of Government reorganization.

Comments on Dye Development

A brief historical summary of the history of the dye industry in the United States, showing its growth from a small unit in the general industrial machine to a tremendous factor in the manufacturing life of the country, was given at the December meeting by Dr. C. G. Derick, in charge of the Research Laboratory of the National Aniline & Chemical Co., Buffalo, N. Y., before the Rochester Section of the American Chemical Society, in the Eastman Building of the University of Rochester. In addition to his historical remarks Dr. Derick also touched upon the problems confronting the industry at present.

Before 1914 about 70 per cent of the annual output of 400,000,000 lb. of dyestuffs was produced in Germany, no other one country producing as much as 10 per cent. England produced about 6½ per cent, France 5½, the United States 5, and Switzerland about 8 per cent. Scientific research can be considered the backbone of the German monopoly. However, had there not been a small industry in this country since 1870 the situation would have been much worse. In speaking of the history of the dye industry in this country Dr. Derick said that back in 1869 out on Buffalo Creek J. F. Schoelfkopf started a small factory. The same building served as stable, factory, laboratory, office and restaurant. The beginning was small and the difficulties were many, such as the Buffalo River rising and floating away part of the factory. This small concern was dependent upon Germany for its apparatus and the intermediates from which the dyes were made. Competition was keen with Germany, which held the monopoly and intended to keep it.

About twenty years ago, however, Schoelfkopf worked out a new black dye and patented it. It proved to be one of the most popular dyes. When he tried to get patents in other countries, however, Germany stepped in and said she had known about it for a long time. Then started one of the hardest fights the dye industry in this country ever had. Germany, seeing she was losing ground, tried then to compromise, divide up markets, etc. There was great rejoicing when the first carload of dye left the small Schoelfkopf factory. The value of an American patent backed by American law cannot be overestimated.

In 1914 Schoelfkopf thought the war would not last very long and having a large supply of intermediates on hand made up dyes and sold them at good profit. But it soon became evident that the war would not soon be over and the dye industry would suffer. Schoelfkopf made contracts with his older men to work out new dyes and share in the profits. In May, 1916, the old building was torn down, in August the research

chemists, Dr. Derick being in charge, went into the new building, and by Christmas of that same year twenty buildings were in operation and putting out from 60 to 70 per cent of the total consumption of this country. This wonderful work was made possible through the thirty-five years of research, experience and hard work. The contractors also deserve much credit for putting up the buildings in record time.

Dr. Derick went on to speak of the work involved in research, which may be divided into two classes—the exploratory function and the developmental function. In the United States about 99 per cent of the research has been along the latter line and this cannot go on; more work must be done in exploration. The research work in dyes must develop the dyestuffs, patent them and work out methods for qualitative analysis. Twenty per cent of the total business was dyes the constitution and components of which were unknown. The great problem then was to work out these unknowns, and this has now been done; there is not an important German secret in the dye industry that has not been solved in the laboratory, but some have not been as yet developed. Another phase of the work is the realization of the fundamental relation between constitution and color. The principal coal-tar products used in the making of dyes are benzene, toluene, naphthalene and anthracene.

The problems of the research man which must be solved in the laboratory are the materials that enter into the specifications, methods of analysis to back up the specifications, study of operations, study of variables and methods of control. The hazard study involving explosives likely to be produced and the effect of materials on the health of the workers is most important.

After the work leaves the research chemist it goes to the research engineering division, where apparatus is decided upon and estimates are made. Then the process goes to the factory and is worked out by a special set of workers under the supervision of the research chemist long enough to get accurate records of cost, etc.

Special difficulties that must be met and overcome are the effect of shutdowns of engineering service, such as of steam or electricity at an important point, which may result in an explosion, death of workers, or spoiled products. Other difficulties are the destructive action of bacteria and yeast to the finished dyestuffs. The patent situation must be continuously watched.

General Fries Advocates Plan to Stimulate Inventive Initiative in C.W.S.

General A. A. Fries, the head of the Chemical Warfare Service, states that some plan of systematic handling of inventions by Government employees is very necessary in the Chemical Warfare Service. As it is there is great need for stimulating inventive initiative and effort. He believes this applies to the whole Government service, but it is of unusual importance in his organization, where the field is so new. Under present conditions, he points out, many Government employees leave the service to develop their ideas so that they may participate in its benefits. Greater incentive must be given Government research workers if maximum progress is made in such matters as the development of war gases, General Fries said. He characterized the attitude of some of the concerns opposing such a plan as being narrow and an inheritance from the days of the alchemist, when all chemical research was hedged about with deep secrecy.

Industrial Investigations in Universities

On Friday evening, Jan. 7, the New York Section of the American Chemical Society was addressed by two prominent professors.

Dr. Warren K. Lewis reported that the new co-operative system established at Mass. Inst. of Tech. is proving highly advantageous both to the graduate students and to the score of industries represented. Co-operative students are chosen competitively on the basis of scholarship shown in their undergraduate work, reliability, personality and ability. A great amount of plant philosophy is imparted to the students and industry is saved the trouble of training raw recruits.

Drs. Ralph H. McKee and E. E. Lyder presented a very comprehensive report of their investigations on the pyrolysis of shale kerogens. The primary decomposition product at about 400 deg. C. was shown to be viscid tarry hydrocarbons which break down under destructive distillation (at 500 to 600 deg. C.) to form secondary products—oils, vapors, gases and free carbon. The investigations also included the determination of physical constants which may be of importance in process design.

Personal

H. FOSTER BAIN has been recommended by the Secretary of the Interior for the directorship of the Bureau of Mines. Dr. F. G. Cottrell's resignation has been accepted by Secretary Payne, effective Jan. 1. Dr. Cottrell has resigned to become chairman of the Division of Chemistry and Chemical Technology of the National Research Council. Both Mr. Bain and Dr. Cottrell will enter upon their new duties immediately. Mr. Bain during the war was assistant director of the Bureau of Mines and is widely known for his work as a consulting mining engineer and as a geologist. He has just returned from a trip to the Far East, where he made examinations of mining properties in ten countries.

Dr. C. B. CLEVENGER has resigned as instructor in the department of chemistry, University of Wisconsin, Madison, Wis., to accept a professorship of agricultural chemistry and head of the department of chemistry of the Manitoba Agricultural College, Winnipeg, Canada.

WILL H. COGHILL of the U. S. Bureau of Mines has gone to Platteville, Wis., to study the sludge problem in the Wisconsin zinc district.

W. C. GRAHAM, formerly of the Great Western Sugar Co. and now having his own business in the Coronado Bldg., Denver, Col., left New York on Jan. 8 to be away for several months on a special mission for the South Porto Rico Sugar Co.

Dr. RALPH E. HALL, formerly of the Geophysical Laboratory of the Carnegie Institution, Washington, D. C., has resigned from the Firestone Rubber Co., Akron, Ohio, to accept a position with the Koppers Co. of Pittsburgh, Pa.

FREDERICK A. HARVEY has resigned from the Semet-Solvay Co. to become technical assistant to the president of the United States Refractories Corporation, which prior to Jan. 1 was known as the Mt. Union Refractories Co.

ELLWOOD HENDRICK, consulting editor of CHEMICAL & METALLURGICAL ENGINEERING, lectured before the Polytechnic Section of the American Institute of the City of New York on Jan. 3 on "The Sense of Smell."

E. L. JORGENSEN, formerly general superintendent of reduction for the Chile Exploration Co. at Chuquicamata, Chile, has after fifteen years with Guggenheim Companies opened an office as consulting engineer in Suite 1429, 150 Nassau St., New York City.

CHARLES H. MILLER of Auburn, N. Y., has started a chemical and physical laboratory for the McIntosh & Seymour Corporation, maker of Diesel engines. The materials used in the manufacture, as well as the coal, oil, etc., will be tested chemically and physically.

PROF. JAMES F. NORRIS has been elected to the chairmanship of the committee in charge of the C. M. Warren Fund of the American Academy of Arts and Sciences, in place of Prof. H. P. Talbot, resigned. The income from the fund is available for the "encouragement and advancement of research in the science or field of chemistry," and may be used to provide the materials required for such investigations or assistant in their execution. The commitee will be glad to receive and consider requests for grants from this fund. They should be addressed to Prof. James F. Norris, Massachusetts Institute of Technology, Cambridge, Mass.

A. A. RACKOFF, Wilkinsburg, Pa., is now specializing on special steel works and labor-saving machinery, teeming devices and coke-oven accessories.

Dr. L. I. SHAW lectured before the Franklin Institute Jan. 6, 1921, on "Smoke and Incendiary Material."

DR. EDGAR FAHS SMITH has been elected president of the American Chemical Society for the year 1921.

At the College of the City of New York Prof. HERBERT R. MOODY has been appointed professor of chemical engineering within the department of chemistry; Asst. Prof. W. L. PRAGER has been promoted to an associate professorship and JOSEPH A. BABOR has been promoted to an instructorship.

The Royal Society of England has awarded the Coply medal to H. T. BROWN for his work on the chemistry of carbohydrates, on the assimilation of atmospheric carbon dioxide by leaves, and on gaseous diffusion through small apertures; the Rumford medal to Lord RAYLEIGH for researches into the properties of gases at high vacua; the Davy medal to C. T. HEYCOCK for his work in physical chemistry, especially on the composition and constitution of alloys, and the Hughes medal to Prof. O. N. RICHARDSON for his work in experimental physics on the passage of electricity through gases, and especially for those relating to the electrons from hot bodies, which he has termed "thermionies."

The British Institution of Mining and Metallurgy has awarded its gold medal to Sir THOMAS KIRKE ROSE in recognition of his eminent services in the advancement of metallurgical science with special reference to the metallurgy of gold.

Current Market Reports

The Chemical and Allied Industrial Markets

New York, Jan. 10, 1921.

Large inquiries were not numerous during the past week in the chemical market but the situation showed signs of recovering from the effects of the recent holidays and producers seemed confident of a slow but gradual improvement in business during the rest of the month. Buyers are generally holding off and seem to be waiting for someone to start the ball rolling. There seems to be little doubt that should someone break the ice consumers will come into the market in force. Prices generally continue weak and subject to shading among leading dealers. Producers are still holding quotations well up to their recently quoted levels for contracts over 1921 in spite of the lack of any considerable business.

Resale *bichromate of soda* was offered at 9¼c. per lb., with some sellers, however, asking 9½c. Trade conditions were not very active and buyers appeared content to await new developments in the market before operating. Offerings were not heavy and February shipments were held at about 1c. premium over spot goods. *Solid caustic soda* opened steady on the spot market with sales recorded at $3.75@$3.80 per 100 lb. This was the general quotation named for domestic and export use and the tone appeared quite steady. No change was noted in contract prices and producers continued to quote 3¾c. per lb., basis 60 per cent works, for forward shipments.

Small lots of American *cyanide of soda* were held at 30c. per lb. by dealers. The French variety sold at prices ranging from 21c to 24c. per lb. Some high-test German was on the market at 23c. English material was rather scarce on spot and was held at 24@26c. per lb. Moderate business in *formaldehyde* was booked at 18½c. per lb. spot in barrels. The market is quoted quite steady at this figure, with small lots held as high as 19@19½c. Wide differences of opinion were he'd as to the *arsenic* market. Some lots of white material were said to have sold as low as 9c. per lb. c.i.f. New York for immediate shipment from Japan. Other holders were quoting 10c. per lb. Spot quotations ranged from 10½ to 11½c., according to quantity and sellers.

The market on *caustic potash* remained in an unsettled condition. Imported material 88-92 per cent strength caused further weakness to the spot market. Consumers were unwilling to enter the market in spite of the bargain prices which were offered through second hands. Prices ranging from 14c. to 16c. per lb. for imported seemed to represent a fair low mark for this material. Domestic producers' quotations were far above these figures.

Producers on American *chlorate of potash* continued to quote 18c. per lb. for goods in warehouse. Second hands offered imported goods as low as 11c. per lb., with practically no response from leading match and powder factories. Demand of late has generally been of a very limited nature. There were some sellers of *nitrite of soda* as low as 6c. per lb. for spot goods and quotations were heard from 6¼ to 6½c. per lb. The inside figure was said to be for round lots and was not general in the open market. The low figure compares with 14c. per lb., the initial price last January, and with the high point touched, 60c. per lb. last March. Resale *bleaching powder* was quoted by dealers at 2½@2¾c. per lb. Some fair sales were recorded in small drums at intermediate prices. The inquiry appeared to be moderate, although enough supplies were around to meet all requirements. A feature of the market was the persistent demand for carload lots of light *soda ash* in single bags at the works. Producers seemed well sold up for immediate business and dealers were not anxious to quote the present market. Spot goods have been taken off the market during the past few days and the general undertone appeared quite steady. Prices ranged from $1.90 to $2.10 per 100 lb. for single bags. Barrels were held at 5c. per 100 lb. premium.

COAL-TAR MARKET

The new year has revealed nothing startling and most factors reported a light demand for small quantities of staple products that have a routine call. Inquiries from European sources showed an increase and seemed to indicate that there is a real need for some items. Opinions from different producers, on the other hand, were that these inquiries of the moment are in the nature of feelers trying out the market. Crude materials are quiet and prices are quotably unchanged from previous reports. While there has been no heavy demand for *anthracene*, there is nevertheless a healthy look and the steady developments along the vat dyes are keeping producers rather light on available material. Manufacturers of intermediates are steady in their views and dealers are also more conservative than they have been as to prices. What little is offered on the open market is held on a firmer basis than heretofore.

Small lot trading of *aniline oil* constituted about the extent of business during the week. The market seemed more steady around 23@25c. per lb., although supplies were easy in most quarters. The market on *aniline salt* showed little change from the former quiet stand. There were no new developments featuring the trade and prices held along the regular range from 27c. to 30c. per lb. Reports from most quarters stated that the market for *dinitrobenzene* is quiet. Supplies were said to be available in moderate volume on a basis of 27@30c. per lb. Consumers of *orthotoluidine* are showing little interest at this time. Producers are steady

in their views around 25@30c. per lb., with fair supplies available. While there were some resale lots of *paranitraniline* floating around the market, the quantity is not large and a firmer view is held as to prices, which range from 93c. to $1 per lb.

Waxes

The wax market in the past few weeks has been exceptionally quiet, with only small orders from domestic consumers noted. The inquiry for *crude beeswax* was moderate but trading in the refined material was very dull. The spot market for *Carnauba wax* saw no change in action, but a fair amount of interest was shown in shipments. No. 3 North Country was held at 20@25c. per lb., with futures available at about 18c. per lb. A limited inquiry was in evidence for *Japan wax*, and with spot material not pressing the market prices remained unchanged at 19@20c. per lb. The market for *scale wax* was unsettled, with offerings in some directions of a liberal nature. *Crude wax* 124 m.p. was available at 6⅜c. per lb., with carload lots a trifle under the figure. Refined 133 m.p. wax was offered at 10½c., with no new business noted.

Coal-Tar Products Market for 1920

The sensational rise of the coal-tar, intermediate and dyestuff markets was directly due to the wave of export business that flooded the country immediately after the severe slump during the latter part of 1919. It was generally supposed that Germany had accumulated a tremendous surplus stock of dyes during the war and the entire world was waiting to see whether this condition was a reality. Rumors were current that German interests were about ready to ship in continuous quantities to the outside markets dyes of every description, and as a result consumers were narrowing their orders to the barest necessities. Stocks were reduced to await the time when prices and quality would reach pre-war levels by the Germans in their efforts to once more rehabilitate themselves to their former commercial supremacy.

During the later months of 1919 there were no signs of any importations of dyes and buyers became pessimistic as to the truth about these hoarded stocks. This was an impetus for live buying and immediately orders were noted in large volume for American-made material. Prices soared to their highest peak during the early months of 1920. With this sudden turn in the trend of business it became evident that American manufacturers were not entirely prepared to meet this overwhelming demand. General conditions in other lines prevented any expansion in the industry, and as stocks became depleted with the demand greater than the supply prices fluctuated. Speculation became the order of the day here and abroad. Buyers were paying fabulous prices in order to get what little there was on the spot market. Principal among export buyers were Japan and the Far East countries. Japan, as was noticed in the chemical industry, speculated blindly. Material was bought at any price and it soon became evident that stocks had accumulated which were sufficient to cover her requirements over a period of a few years. The result was inevitable. A chaotic condition arose in Japan when banks began to call their loans on speculative holdings and also to refuse any additional credits. In order to save themselves the Japanese turned from the buying end to the selling. Large holdings were brought back to the American market at sacrifice prices. Prices began to break rapidly and domestic consumers, who had been willfully neglected during the foreign rush, took the upper hand. Stocks moved sluggishly in view of the fact that material was offered at bargain prices. The market became demoralized through these forces and it is in this condition that the coal-tar and intermediate markets find themselves at the turn of the year.

There were many factors together with the enormous export demand that hindered any additional production. The coal strike reduced supplies of all crude-tar manufacturers. Shortage of coal forced practically all of the byproduct coke plants to work on greatly reduced schedules. The car shortage, railroad inefficiency and the unusually hard winter added to the difficulties of American producers. It became evident that some material had to be imported. Naphthalene led among speculators and soon an oversupply followed the rapid slump in business. Large holders began to offer their purchases for resale at prices far below manufacturers' quotations. The same condition held true on all other coal-tar products.

COMPARATIVE PRICES OF COAL-TAR PRODUCTS. JANUARY-DECEMBER, 1920

	Jan.	March	July	Oct.	Dec.
Benzene, c.p. gal.	$0.30	$0.31	$0.37	$0.37	$0.32
Cresylic acid, 95-97%, gal.	.90	.95	1.10	1.05	.90
Cresylic acid, 97-99%, gal.	.94	1.00	1.20	1.15	.95
Dip oil, lb.	.45	.45	.45	.40	.38
Solvent naphtha, water white, gal.	.26	.27	.32	.32	.30
Toluene, water white, gal.	.32	.36	.43	.40	.33
Xylene, pure, gal.	.45	.50	.50	.50	.42
H-acid, per lb.	2.00	1.95	2.25	1.70	1.40
Phthylic anhydride, lb.	.85	.75	.60	.65	.60
Salicylic acid, U.S.P., lb.	.60	.60	.55	.37	.35
Alpha naphthylamine, lb.	.42	.45	.55	.50	.40
Aniline oil, lb.	.36	.38	.36	.30	.22
Aniline salt, lb	.40	.44	.45	.38	.27
Anthracene, 80%, lb.	.80	.85	1.00	1.00	.90
Benzaldehyde, (F.F.C.), lb.	2.00	2.00	2.00	2.00	2.00
Benzidine, base, lb.	1.35	1.35	1.40	1.20	1.00
Benzidine, sulphate, lb.	1.05	1.10	1.25	1.10	.85
Beta Naphthol, tech., lb.	.55	.65	.88	.75	.40
Dichlorbenzene, lb.	.10	.10	.09	.08	.08
Dnitrobenzene, lb.	.30	.32	.36	.35	.35
Diethylaniline, lb.	1.40	1.60	1.50	1.50	1.35
Dimethylaniline, lb.	.90	.90	1.30	1.00	.70
Dinitrophenol, lb.	.40	.45	.42	.40	.40
Diphenylamine, lb.	.80	.82	.87	.80	.70
Naphthalene, flake, lb.	.08	.10	.16	.13	.08
Naphthalene, ball, lb.	.09	.11	.17	.14	.08½
Nitrobenzene, lb.	.16	.17	.17	.15	.14
Orthonitrotoluene, lb.	.23	.27	.28	.25	.25
Paraphenylenediamine, lb.	3.00	3.00	3.00	2.50	2.25
Para amidophenol, base, lb.	2.60	2.60	2.60	2.50	2.10
Para amidophenol, Hcl; lb.	2.85	2.85	2.85	2.75	2.20
Paradichlorbenzene, lb.	.15	.15	.15	.15	.12
Paranitraniline, lb.	1.30	1.45	1.45	1.20	.93
Phenol, lb.	.14	.20	.18	.12	.12
Resorcinol, tech, lb.	4.50	4.50	4.50	2.85	2.75
Resorcinol, pure, lb.	7.50	7.50	6.50	4.00	3.60
Toluidine, lb.	1.65	1.65	1.70	1.70	1.35

The 1921 prospect for business seems very indefinite and will remain so until some settlement is reached on the tariff question. No point is of such crucial significance to the industry at the present time as the passage of suitable protective measures by Congress. The present scale of operation as well as the expert supervision required causes enormous expenses and makes it necessary for the American manufacturer to charge more for his product than the German. Some definite action in this matter will immediately set the industry on a firm basis and development work which will follow will be one of the greatest factors in reducing the cost of American products to the consumers. Prices will probably rise without any resumption of new business, as present stocks have been generally reduced to a minimum. It is problematical whether this will occur during the first quarter. The only logical solution is that the rebound will be gradual and that business will increase until a normal volume of trade is reached. Prices are much lower now than at the beginning of 1920 and in some cases are even below the cost of production. Any inequalities will undoubtedly be removed in the immediate future and legitimate prices will be set forth which will include legitimate profits.

The St. Louis Market

St. Louis, Jan. 5, 1921.

A more cheerful tone has been evident in the heavy chemical market during the last week. Producers report many domestic consumers renewing contracts at the price levels established around the middle of December. Shipments on contracts have picked up appreciably since the first of the year also. Although spot sales have not increased to any great extent the number of inquiries has increased. One helping factor is the almost complete absence from the market of small distressed lots of heavy chemicals.

Quotations have changed in only one instance, and producers are manipulating their production in such a manner that their stocks of heavy chemicals will not accumulate beyond control. In a few instances a quickening demand has found supply low.

Demand for the 98 deg. *sulphuric acid* is still slow and the price has dropped to $24 per ton f.o.b. works from the previous quotation of $25 per ton. The 66 deg. acid continues in strong demand, the greater portion of the production going to the oil refineries. Quotations are stable at $20@$21 per ton and 1¾c. per lb. in carboys, carload lots. The demand for the 60 deg. sulphuric acid has shown flashes of activity in the last few days and the current price is $16 per ton and 1¼c. per lb. in carboys. *Oleum* has shared in this increased activity, producers reporting inquiries good, although orders have picked up only slightly. It is being offered at $28.50 per ton.

Producers report that users are calling more actively for *muriatic acid*. Stocks were not large and prices are holding firmly at $25 per ton in bulk and 1¾@2c. per lb.

Sodium bisulphate is quiet, but there are no very large lots to offer and the greater part of the production is being shipped on contract. The nominal quotation is $7@$8 per ton.

Zinc chloride is not in exceptionally strong demand, but there has been no further decrease in quotations. It is being offered at $4.15 per 100 lb.

The *nitric acid* market is quiet and quotations are $7 per 100 lb. for the 36 deg. test and $10 per 100 lb. for 42 leg. Quotations on standard mixed acid are unchanged.

The Chicago Market

Chicago, Jan. 5, 1921.

A very definite tendency toward a stronger market is felt on all sides since the turn of the calendar. This has not been evidenced by any marked price advances nor by increased demand, but rather by the very definite decrease in the volume of supplies in the stocks of second hands. The trend of the past few months has been toward the elimination of the speculator and the vest-pocket trader, who were so largely responsible for the extreme height to which prices rose last year. With their activity reduced to a minimum and with markets largely in the hands of producers, prices are bound to be more stable and to be based on actual worth.

With consumption going on at a day-to-day rate and with production materially retarded, no oversupply in any item seems probable. From this it is deduced that while prices may not necessarily be at their bottom level they are very near to it. Dealers and manufacturers are a unit in expressing the opinion that business during the coming season is going to be good.

Heavy Chemicals

Little action, but prices firmly held, in general, has been the story of the past two weeks. In the soda group only routine orders are being placed, but spot stocks seem to be getting low. *Soda ash* offerings are at $2 per 100 lb. now, against $1.85 ten days ago. All supplies are firmly held at the quoted price. *Caustic soda* has been moving in good volume, orders averaging small but running to a good total. Today's quotation is $3.85@$4.15 per 100 lb. *Sal soda*, at $2.25 per 100 lb., is in routine demand only. No large stocks of *sodium bichromate* are to be found and prices are held at 12@13c. per lb., with demand steady.

The *alcohol* market is still in a bad way. Production of *methyl* grade has been seriously curtailed and with the gradual depletion of resale stocks current quotations of $1.80 per gal. for 97 per cent should represent about the bottom of the market. *Ethyl* grade, owing to the uncertainty of future production costs, is uncertain as regards supply. At present the market is quiet at $5.15 per gal. for 190 proof. Supply of *denatured* is still greatly in excess of demand, and quoted price of 80@90c. indicated the wide range of price offerings.

Glycerine remains at a very low ebb, buyers showing no interest and holders of stock apparently being content to hold. The c.p. grade, held at 19c. per lb. f.o.b. works, is exciting no interest and saponification grade is offered at 12c., with but little business resulting. *Quicksilver*, quoted at $43@$45 per flask, is said to be cheaper than production cost, in spite of which demand remains light.

Acids are facing a weak market. Price range does not seem to mean much to consumers, who are content to limit purchases to their day-to-day requirements. Current quotations, most of which can be shaded, are: 66 deg. *sulphuric*, $24 per ton; 36 deg. *nitric*, $6.50@$6.75 per 100 lb.; *muriatic*, 18 deg., $1.85@$2 per 100 lb.; *acetic*, glacial, 10½@11½c. per lb., 56 per cent, 5½@5¾c. per lb. Production of all acids is being curtailed.

Vegetable Oils

Continued weakness is noted in this line, small volume of transactions and lowering prices being the order of the day. Quotations are largely nominal as large stocks are still in second hands and most any offer will be made to induce sales. *Linseed oil*, unchanged in quotation, could actually be bought at 76c. per gal. in car lots. *Cottonseed oil*, quoted at 6c. per lb. f.o.b. point of production, is not only below cost but is also lower than the appraisement value upon which bank loans were made a few months ago. Actual transactions are few. *Corn oil*, firmed up in price by reduced production, is held at 7c. per lb. f.o.b. Chicago, but no reports are heard of any sales of importance. *Coconut oil*, in spite of rumored impending shortage, excites no interest at the curent price from local warehouse of 12½c. per lb. for crude and 15c. for deodorized.

Naval Stores

Owing to the widespread depression in the various industries which use naval stores prices are held at low levels and but little real business is being done. Very recent improvements in foreign exchange rates may make possible increased export business, which has been negligible for some weeks. Current quotation on *turpentine* in barrels by the carload f.o.b. Chicago is $1.09½ per gal.; in drums it is 6c. lower. Better grades of *rosin* are quoted at $10.25 per 100 lb., and lower grades at $9.90@$10. Distilled *pine oil*, under fair demand, remains unchanged.

Coal-Tar Products

The dye trade shows every indication that stocks in consumers' hands are low, which promises well for the future. The recently reported resumption of work in numerous textile plants, although on a reduced scale, is another favorable factor. Great interest is shown in the action to be taken by Congress in placing a protective tariff on products of the coal-tar industry. Quotations on crudes, while firm, are largely nominal, as transactions are few. *Phenol* is offered at 10@12c. per lb., sales at any figure being light. Spot stocks are reported as diminishing. *Toluol* shows a similar wide price range, offerings ranging from 32c. to 36c. per gal. *Benzene*, 90 per cent, is quoted at 33c. per gal., and *naphthalene* in both ball and flake form at 9@10c. per lb. All coal-tar acids are reported as very quiet, current quotations being purely nominal. *Benzoic* is offered at 65c. per lb. for technical grade and 70c. for U.S.P.; *picric* at about 35c.; *salicylic* at 36@38c. for U.S.P.

The Iron and Steel Market

Pittsburgh, Pa., Jan. 7, 1921.

Independent pipe mills have reduced their prices to the Steel Corporation level. The movement was inaugurated by the Republic Iron & Steel Co., which distributed new list prices under date of Dec. 31, other independents following in short order, some lists being dated Jan. 1 and others Jan. 3. The difference in dates is immaterial, they merely fixing the time for readjustment of prices on current shipments against old contracts, and Jan. 1 was not a shipping date.

Pipe was the only important steel mill product requiring readjustment from the advanced independent market, and thus the return of the independent steel market to the Steel Corporation or Industrial Board level was completed, without a day to spare, within the limits of the calendar year. The real flight of the independent market had only begun in 1920. There were some advanced prices secured late in 1919, but at the time the advances were regarded as simply involving a premium for early delivery. Later, or in 1920,

the independents would not sell for any delivery except at their advanced prices, while formerly they simply refused to sell for extended delivery at all.

Operations

The trend in independent mill operations is downward, but there has been no general closing. Many mills are closed but others are operating at rates up to perhaps 50 or 60 per cent of capacity. The general average among independents is perhaps not over 20 per cent. The Carnegie Steel Co. has been producing ingots at fully 96 per cent of rated capacity, while the National Tube Co. is running full. These two subsidiaries have 53 per cent of the Steel Corporation's total ingot capacity. The Illinois Steel Co. is reported to be operating at 85 per cent. The general average of the Steel Corporation is probably about 92 per cent.

If the independents are operating at 20 per cent and the Steel Corporation at 92 per cent, the general average for the industry is about 52 per cent of capacity, or about 65 per cent of the average rate during the period of heavy demand, the first nine months of 1920. In that period the mills averaged only 80 per cent, being held down by shortages of cars and fuel, and in spots a little labor shortage.

Predictions that were being made in December that there would be an "improvement" in the steel trade immediately after the turn of the year need not be taken seriously. There could be an increase in buying without its offsetting the exhaustion of old contracts, and no signs even of that are now seen. With steel production and shipments at 65 per cent of the former rate one may doubt whether the present rate can be maintained, for it is not reasonable to suppose that steel consumption has decreased by only 35 per cent. Indeed, some steel producers candidly state that they know some of the steel they are shipping is not going into actual consumption, although their customers are willing to receive it. The trend of the next few weeks, therefore, is likely to be a downward trend in production. It is from a rate lower than the present that recovery is to start.

Price Prospects

A common prediction was that almost as soon as the independents reduced their prices to the Steel Corporation level they would begin to shade the new prices. The prediction did not reckon with present conditions, when no new business of importance is developing. At the moment the chief recourse of the independents, in endeavoring to secure business, would be to take business from the Steel Corporation. That would be difficult if not impossible, but in any event would not be attempted, for obvious reasons.

The present prospect seems to be, therefore, that prices will remain as they are for a time, with occasional shading, no doubt, until some substantial volume of new business develops. With a light operation costs are high, but a little additional operation would not mend matters a great deal. The lowest prices will probably be seen when there is hope that by cutting prices a reasonably full operation can be secured. Meanwhile costs will be coming down. There is scarcely any doubt that eventually, and before there is an upturn in prices, there will be a somewhat lower level than now obtains, but that is not for the immediate future.

While there have been some wage reductions among the independent steel producers the movement is very far from general. It appears to be the common impression that the present is not an appropriate time. The independent mills are largely idle in any event. As to the Steel Corporation, there is no expectation that it will take any action in the matter of wages for quite a while.

Pig Iron

The prediction made last week as to bessemer and basic pig iron prices is borne out, as there are furnace offerings this week at $3 decline, $32 for bessemer and $30 for basic at valley furnaces. Foundry is not clearly defined, but seems quotable at $33, a decline of $2. There is no inquiry, and the few furnaces still in blast contemplate going out as they complete orders or make up enough iron to take care of orders in hand. No unsold pig iron is being made.

General Chemicals

CURRENT WHOLESALE PRICES IN NEW YORK MARKET

		Carlots	Less Carlots
Acetic anhydride	lb.	–	$0.55 – $0.60
Acetone	lb.	$0.13 – $0.13½	13½ – .14
Acid, acetic, 28 per cent	100 lbs.	3.00 – 3.25	3.50 – 3.75
Acetic, 56 per cent	100 lbs.	6.00 – 6.25	6.50 – 6.75
Acetic, glacial, 99½ per cent, carboys,	100 lbs.	10.50 – 11.00	11.25 – 11.50
Boric, crystals	lb.	.14½ – .15	15½ – .16
Boric, powder	lb.	.15½ – .16½	17 – .18
Citric	lb.	–	50 – .52
Hydrochloric	100 lb.	1.85 – 2.25	2.75 – 3.00
Hydrofluoric, 52 per cent	lb.	.15 – .16	16½ – .18
Lactic, 44 per cent tech	lb.	.10 – .11	11½ – .12
Lactic, 22 per cent tech	lb.	04½ – .05½	06 – .07
Molybdic, C. P	lb.	4.00 – 4.50	4.50 – 5.00
Muriatic, 20 deg. (see hydrochloric)		–	–
Nitric, 40 deg	lb.	.07 – .07½	.08 – .08¾
Nitric, 42 deg	lb.	.08½ – .09	09½ – .10
Oxalic, crystals	lb.	.18¼ – .18½	.19 – .20
Phosphoric, Ortho, 50 per cent solution	lb.	.18 – .18½	.18½ – .19
Picric	lb.	.28 – .35	.40 – .50
Pyrogallic, resublimed	lb.	–	2.30 – 2.40
Sulphuric, 60 deg., tank cars	ton	–	–
Sulphuric, 60 deg., drums	ton	–	14.00 – 15.00
Sulphuric, 66 deg., tank cars	ton	18.00 – 19.00	–
Sulphuric, 66 deg., drums	ton	21.00 – 22.00	22.50 – 23.00
Sulphuric, 66 deg., carboys	ton	–	–
Sulphuric, fuming, 20 per cent (oleum) tank cars	ton	23.00 – 24.90	–
Sulphuric, fuming, 20 per cent (oleum) drums	ton	25.00 – 26.00	26.50 – 27.00
Sulphuric, fuming, 20 per cent (oleum) carboys	ton	32.00 – 35.00	40.00 –
Tannic, U. S. P	lb.	–	1.30 – 1.35
Tannic (tech.)	lb.	.48 – .50	.51 – .52
Tartaric, crystals	lb.	–	.33 – .35
Tungstic, per lb. of WO	lb.	–	1.20 – 1.40
Alcohol, Ethyl (nominal)	gal.	–	5.25 – 5.50
Alcohol, Methyl (see methanol)		–	–
Alcohol, denatured, 188 proof	gal.	–	.70 – .72
Alcohol, denatured, 190 proof	gal.	–	.75 – .77
Alum, ammonia lump	lb.	04½ – 04¾	.05 – .05½
Alum, potash lump	lb.	05½ – .06	06½ – .07
Alum, chrome lump	lb.	.13 – .13½	.14 – .14½
Aluminum sulphate, commercial	lb.	02¼ – .03	03¼ – .03½
Aluminum sulphate, iron free	lb.	.03½ – .03¾	.04 – .04½
Aqua ammonia, 26 deg., drums (750 lb.)	lb.	06¼ – .07	.07½ – .08½
Ammonia, anhydrous, cyl. (100-150 lb.)	lb.	.30 – .32	.33 – .35
Ammonium carbonate, powder	lb.	.14 – .14½	.14½ – .15
Ammonium chloride, granular (white salamoniac) (nominal)	lb.	.10½ – .11	.11¼ – .11½
Ammonium chloride, granular (gray salammoniac)	lb.	.09½ – .09¾	.10 – .10½
Ammonium nitrate	lb.	.09 – .09½	.10 – .10½
Ammonium sulphate	lb.	.03½ – .03¾	.04 – .04¼
Amylacetate	gal.	–	4.25 – 4.50
Amylacetate tech	gal.	–	3.50 – 3.75
Arsenic oxide, lumps (white arsenic)	lb.	.10½ – .11	.11¼ – .11½
Arsenic, sulphide, powdered (red arsenic)	lb.	.15 – .15½	.15 – .16
Barium chloride	ton	75.00 – 80.00	85.00 – 90.00
Barium dioxide (peroxide)	lb.	.24 – .25	.26 – .27
Barium nitrate	lb.	.10 – .10¼	.10½ – .11
Barium sulphate (precip.) (blanc fixe)	lb.	.04½ – .05	.05½ – .06
Bleaching powder (see calc. hypochlorite)		–	–
Blue vitriol (see copper sulphate)		–	–
Borax (see sodium borate)		–	–
Brimstone (see sulphur, roll)		–	–
Bromine	lb.	.50 – .52	.54 – .56
Calcium acetate	100 lbs.	2.00 – 2.05	–
Calcium carbide	lb.	.04 – .04½	.04 – .05
Calcium chloride, fused, lump	ton	27.00 – 29.00	30.00 – 32.00
Calcium chloride, granulated	lb.	.02 – .02½	.02½ – .03
Calcium hypochlorite (bleach'g powder)	lb.	.02 – .03	.03¼ – .03½
Calcium peroxide	lb.	–	1.25 – 1.30
Calcium phosphate, monobasic	lb.	–	.16 – .18
Calcium sulphate, pure	lb.	–	.05 – .06
Camphor	lb.	–	.88 – .90
Carbon bisulphide	lb.	.08 – .08½	.09 – .09½
Carbon tetrachloride, drums	lb.	.11 – .11¼	.11½ – .12
Carbonyl chloride (phosgene)	lb.	–	.60 – .75
Caustic potash (see potassium hydroxide)		–	–
Caustic soda (see sodium hydroxide)		–	–
Chlorine, gas, liquid-cylinders (100 lb.)	lb.	.09 – .09½	.10 – .10½
Chloroform	lb.	–	.43 – .50
Cobalt oxide	lb.	–	3.90 – 4.00
Copperas (see iron sulphate)		–	–
Copper carbonate, green precipitate	lb.	.22 – .22½	.24 – .25
Copper cyanide	lb.	–	.40 – .50
Copper sulphate, crystals	lb.	.06½ – .06	.07 – .07½
Cream of tartar (see potassium bitartrate)		–	–
Epsom salt (see magnesium sulphate)		–	–
Ethyl Acetate Com. 85%	gal.	–	1.05 – 1.10
Ethyl Acetate pure (acetic ether 98% to 100%)		–	–
Formaldehyde, 40 per cent	lb.	.18½ – .18	.19 – .19½
Fusel oil, ref	gal.	–	3.50 – 3.60
Fusel oil, crude	gal.	–	2.75 – 3.00
Glauber's salt (see sodium sulphate)		–	–
Glycerine, C. P. drums extra	lb.	–	.20 – .21
Iodine, resublimed	lb.	–	3.85 – 4.00
Iron oxide, red	lb.	–	.10 – .20
Iron sulphate (copperas)	100 lb.	1.50 – 1.75	2.00 – 2.25
Lead acetate, normal	lb.	–	.14½ – .16
Lead arsenate (paste)	lb.	.13 – .14	.14½ – .15
Lead nitrate, crystals	lb.	–	.90 – 1.00
Litharge	lb.	.10 – .10½	.10½ – .11½
Lithium carbonate	lb.	–	1.50 –
Magnesium carbonate, technical	lb.	.10½ – .11	.11½ – .12
Magnesium sulphate, U. S. P	100 lb.	3.00 – 3.25	–
Magnesium sulphate, commercial	100 lb.	–	1.50 – 1.75
Methanol, 95%	gal.	–	1.60 – 1.65
Methanol, pure	gal.	–	1.85 – 1.95
Nickel salt, double	lb.	–	.12 – .12½
Nickel salt, single	lb.	–	.13 – .13½
Phosgene (see carbonyl chloride)		–	–
Phosphorus, red	lb.	.45 – .46	.47 – .50
Phosphorus, yellow	lb.	–	.35 – .37
Potassium bichromate	lb.	.17 – .17¼	.17½ – .18

		Carlots	Less Carlots
Potassium bitartrate (cream of tartar)	lb.	$ – $	$0.38–$0.40
Potassium bromide, granular	lb.	–	.35 – .40
Potassium carbonate, U. S. P.	lb.	.35 – .40	.45 – .50
Potassium carbonate, crude	lb.	.11 – .11½	.11½ – .12
Potassium chlorate, crystals	lb.	.11 – .12	.13 – .18
Potassium cyanide	lb.	–	.65 – .70
Potassium hydroxide (caustic p tash)	lb.	.14 – .14½	.15 – .16
Potassium muriate	ton	75.00 – 80.00	
Potassium iodide	lb.	–	3.00 – 3.20
Potassium nitrate	lb.	.11½ – .12	.12½ – .13
Potassium permanganate	lb.	.60 – .63	.65 – .70
Potassium prussiate, red	lb.	.60 – .62	.63 – .65
Potassium prussiate, yellow	lb.	.31 – .31½	.32 – .33
Potassium sulphate (powdered)	ton	$225.00 – 230.00	
Rochelle salts (see sodium potas tartrate)			
Salammoniac (see ammonium chloride)			
Sal soda (see sodium carbonate)		–	–
Salt cake	ton	–	40.00 – 45.00
Silver cyanide	oz.	–	1.25 –
Silver nitrate	oz.	–	.43 – .45
Soda ash, light	100 lb.	1.90 – 2.00	2.10 – 2.30
Soda ash, dense	100 lb.	2.30 – 2.50	2.75 – 3.00
Sodium acetate	lb.	.05½ – .05½	.06 – .06½
Sodium bicarbonate	100 lb.	2.45 – 2.60	2.65 – 3.00
Sodium bichromate	lb.	.09½ – .09½	.09½ – .10
Sodium bisulphate (nitre cake)	ton	7.00 – 7.50	8.00 – 11.00
Sodium bisulphite powdered, U.S.P.	lb.	.06½ – .07	.07½ – .08
Sodium borate (borax)	lb.	.07 – .07½	.07½ – .08
Sodium carbonate (sal soda)	100 lb.	2.00 – 2.25	2.50 – 2.75
Sodium chl rate	lb.	.10 – .10½	.10½ – .11
Sodium cyanide, 96-98 per cent	lb.	.21 – .23	.24 – .30
Sodium fluoride	lb.	.17 – .17½	.17½ – .18½
Sodium hydroxide (caustic soda)	100 lb.	3.75 – 4.00	4.25 – 4.35
Sodium hyposulphite	lb.	–	.03 – .04
Sodium nitrate	100 lb.	2.85 –	3.00 –
Sodium nitrite	lb.	.06 – .06½	.06½ – .07
Sodium peroxide, powdered	lb.	.30 – .31	.32 – .34
Sodium phosphate, dibasic	lb.	.03½ – .04½	.04½ – .05
Sodium potassium tartrate (Rochelle salts)	lb.	–	.33 – .35
Sodium prussiate, yellow	lb.	.17 – .17½	.17½ – .18
Sodium silicate, solution (40 deg.)	lb.	.01½ – .01½	.02 – .02½
Sodium silicate, solution (60 deg.)	lb.	.03 – .03½	.03½ – .04
Sodium sulphate, crystals (Glauber's salt)	100 lbs.	1.75 – 2.00	2.25 – 2.50
Sodium sulphide, crystal, 60-62 per cent (conc.)	lb.	.06 – .06½	.07 – .07½
Sodium sulphite, crystals	lb.	.04 – .04½	.04½ – .05
Strontium nitrate, powdered	lb.	.20 – .20½	.21 – .22
Sulphur chl ride, red	lb.	.08 – .09	.10 – .10½
Sulphur, crude	ton	16.00 – 20.00	–
Sulphur dioxide, liquid, cylinders	lb.	.09 –	.10 – .12
Sulphur (sublimed), flour	100 lb.	–	3.70 – 4.35
Sulphur, roll (brimstone)	100 lb.	–	3.40 – 3.90
Tin bichloride, 50 per cent	lb.	.18 – .19	–
Tin oxide	lb.	–	.50 – .51
Zinc carbonate, precipitate	lb.	.16 – .18	.19 – .20
Zinc chloride, gran	lb.	.11½ – .12	.12½ – .13
Zinc cyanide	lb.	.45 – .49	.50 – .60
Zinc dust	lb.	.12 – .13	.13½ – .14
Zinc oxide, XX	lb.	.10 – .10½	.11 – .11½
Zinc sulphate	lb.	.03½ – .03¾	.04 – .06

Coal-Tar Products

NOTE—The following prices are for original packages in large quantities:

Alpha-naphthol, crude	lb.	$1.10 — $1.15
Alpha-naphthol, refined	lb.	1.45 — 1.50
Alpha-naphthylamine	lb.	.40 — .44
Aniline oil, drums extra	lb.	.23 — .25
Aniline salts	lb.	.27 — .30
Anthracene, 80% in drums (100 lb.)	lb.	.85 — 1.00
Benzaldehyde (f.f.e.)	lb.	2.00 — 2.10
Benzidine, base	lb.	1.00 — 1.10
Benzidine sulphate	lb	.85 — .90
Benzoic acid, U.S.P.	lb.	.70 — .75
Benzoate of soda, U.S.P.	lb.	.75 — .85
Benzene, pure, water-white, in drums (100 gal.)	gal.	.30 — .35
Benzene, 90%, in drums (100 gal.)	gal.	.28 — .32
Benzyl chloride, 95-97%, refined	lb.	.35 — .40
Benzyl chloride, tech.	lb.	.25 — .35
Beta-naphthol benzoate	lb.	3.50 — 4.00
Beta-naphthol, sublimed	lb.	.75 — .80
Beta-naphthol, tech (nominal)	lb.	.38 — .42
Beta-naphthylamine, sublimed	lb.	2.25 — 2.40
Cresol, U. S. P., in drums (100 lb.)	lb.	.16 — .18
Ortho-cresol, in drums (100 lb.)	lb.	.23 — .25
Cresylic acid, 97–99%, straw color, in drums	gal.	.95 — 1.00
Cresylic acid, 95-97%, dark, in drums	gal.	.90 — .95
Cresylic acid, 50%, first quality, drums	gal.	.65 — .75
Dichlorbenzene	lb.	.06½ — .15
Diethylaniline	lb.	1.35 — 1.40
Dimethylaniline	lb.	.65 — .90
Dinitrobenzene	lb.	.27 — .30
Dinitroclorbenzene	lb.	.25 — .30
Dinitronaphthalene	lb.	.40 — .45
Dinitrophenol	lb.	.40 — .45
Dinitrotoluene	lb.	.27 — .30
Dip oil, 25%, tar acids, car lots, in drums	gal.	.38 — .40
Diphenylamine	lb.	.70 — .75
H-acid	lb.	1.40 — 1.55
Meta-phenylenediamine	lb.	1.25 — 1.30
Monochlorbenzene	lb.	.15 — .16
Monoethylaniline	lb.	1.75 — 2.25
Naphthalene crushed, in bbls. (250 lb.)	lb.	.08 — .08½
Naphthalene, flake	lb.	.08 — .08½
Naphthalene, balls	lb.	.09 — .09½
Naphthionic acid, crude	lb.	.70 — .75
Nitrobenzene	lb.	.12 — .15
Nitro-naphthalene	lb.	.40 — .50
Nitro-toluene	lb.	.18 — .25
Ortho-amidophenol	lb.	3.20 — 3.75
Ortho-dichlor-benzene	lb.	.15 — .20
Ortho-nitro-phenol	lb.	.75 — .80
Ortho-nitro-toluene	lb.	.23 — .30
Ortho-toluidine	lb.	.25 — .30
Para-amidophenol, base	lb.	1.90 — 2.00
Para-amidophenol, HCl	lb.	2.20 — 2.25
Para-dichlorbenzene	lb.	.10 — .15
Paranitroaniline	lb.	.93 — 1.00
Para-nitrotoluene	lb.	1.25 — 1.40
Para-phenylenediamine	lb.	2.20 — 2.35
Para-toluidine	lb.	1.70 — 1.80
Phthalic anhydride	lb.	.60 — .70
Phenol, U. S. P., drums (dest.), (240 lb.)	lb.	.09 — .10
Pyridine	gal.	2.00 — 3.50
Resorcinol, technical	lb.	2.75 — 2.80
Resorcinol, pure	lb.	3.60 — 3.80
Salicylic acid, tech., in bbls. (110 lb.)	lb.	.30 — .32
Salicylic acid, U. S. P.	lb.	.33 — .35
Salol	lb.	.85 — .95
Solvent naphtha, water-white, in drums, 100 gal.	gal.	.28 — .32
Solvent naphtha, crude, heavy, in drums, 100 gal.	gal.	.16 — .18
Sulphanilic acid, crude	lb.	.32 — .35
Tolidine	lb.	1.35 — 1.40
Toluidine, mixed	lb.	.45 — .55
Toluene, in tank cars	gal.	.30 — .32
Toluene, in drums	gal.	.33 — .35
Xylidines, drums, 100 gal.	lb.	.45 — .50
Xylene, pure, in drums	gal.	.42 — .45
Xylene, pure, in tank cars	gal.	.45 —
Xylene, commercial, in drums, 100 gal	gal.	.33 — .35
Xylene, commercial, in tank cars	gal.	.30 —

Waxes

Prices based on original packages in large quantities.

Beeswax, refined, dark	lb.	$0.24 — $0.26
Beeswax, refined, light	lb.	.27 — .28
Beeswax, white pure	lb.	.35 — .40
Carnauba, No. 1	lb.	.85 — .90
Carnauba, No. 2, North Country	lb.	.40 — .42
Carnauba, No. 3, North Country	lb.	.20 — .25
Japan	lb.	.19 — .20
Montan, crude	lb.	.07 — .08
Paraffine waxes, crude match wax (white) 105-110 m.p.	lb.	.06½ — .06½
Paraffine waxes, crude, scale 124-126 m.p.	lb.	.06½ — .06½
Paraffine waxes, refined, 118-120 m.p.	lb.	.07 — .07½
Paraffine waxes, refined, 125 m.p.	lb.	.07½ — .08
Paraffine waxes, refined, 128-130 m.p.	lb.	.08½ — .09
Paraffine waxes, refined, 133-135 m.p.	lb.	.10½ — .11
Paraffine waxes, refined, 135-137 m.p.	lb.	.11½ — .12
Stearic acid, single pressed	lb.	.14½ — .15
Stearic acid, double pressed	lb.	.15½ — .15½
Stearic acid, triple pressed	lb.	.15¾ — .16¼

Flotation Oils

All prices are f.o.b. New York unless otherwise stated, and are based on carload lots. The oils in 50-gal. bbls., gross weight, 500 lb.

Pine oil, steam dist., sp.gr., 0.930-0.940	gal.	$1.90
Pine oil, pure, dest. dist.	gal.	1.50
Pine tar oil, ref., sp.gr. 1.025-1.035	gal.	.48
Pine tar oil, crude, sp.gr. 1.025-1.035 tank cars f.o.b. Jacksonville, Fla.	gal.	.35
Pine tar oil, double ref., sp.gr. 0.965-0.990	gal.	.75
Pine tar, ref., thin, sp.gr., 1.080-1.960	gal.	.36
Turpentine, crude, sp. gr., 0.900-0.970	gal.	1.25
Hardwood oil, f.o.b. Mich., sp.gr., 0.960-0.990	gal.	.35
Pinewood creosote, ref.	gal.	.52

Naval Stores

The following prices are f.o.b. New York for carload lots.

Rosin B-D, bbl	280 lb.	$8.75	— .....
Rosin E-I	280 lb.	8.75	— .....
Rosin K-N	280 lb.	8.75	— .....
Rosin W. G.-W. W.	280 lb.	9.00	— .....
Wood rosin, bbl.	280 lb.	9.00	— .....
Spirits of turpentine	gal.	.75	— .....
Wood turpentine steam dist	gal.	.73	— .....
Wood turpentine, dest. dist.	gal.	.73	— .....
Pine tar pitch, bbl	200 lb.	.....	— 8.50
Tar, kiln burned, bbl. (500 lb.)	bbl.	.....	— 15.00
Retort tar, bbl.	500 lb.	15.00	— 15.50
Rosin oil, first run	gal.	.60	— .....
Rosin oil, second run	gal.	.62	— .....
Rosin oil, third run	gal.	.75	— .....

Solvents

73-76 deg., steel bbls. (85 lb.)	gal.	$0.41
70-72 deg., steel bbls. (85 lb.)	gal.	.39
68-70 deg., steel bbls. (85 lb.)	gal.	.38
V. M. and P. naphtha, steel bbls. (85 lb.)	gal.	.30

Crude Rubber

Para—Upriver fine	lb.	$0.18½	— $0.19
Upriver coarse	lb.	.14	— .14½
Upriver caucho ball	lb.	.14½	— .14¾
Plantation—First latex crepe	lb.	.17	— .....
Ribbed smoked sheets	lb.	.16½	— .....
Brown crepe, thin, clean	lb.	.16	— .....
Amber crepe No. 1	lb.	.17	— .....

Oils

VEGETABLE

The following prices are f.o.b. New York for carload lots.

Castor oil, No. 3, in bbls	lb.	$0.10	— $0.11½
Castor oil, AA, in bbls	lb.	.12	— .13
China wood oil, in bbls. (f.o.b. Pac. coast)	lb.	.08½	— .09
Cocoanut oil, Ceylon grade, in bbls	lb.	.13	— .13½
Cocoanut oil, Cochin grade, in bbls	lb.	.13½	— .14
Corn oil, crude, in bbls	lb.	.09	— .09½
Cottonseed oil, crude (f. o. b. mill)	lb.	.06	— .07
Cottonseed oil, summer yellow	lb.	.08½	— .08¾
Cottonseed oil, winter yellow	lb.	.09	— .09½
Linseed oil, raw, car lots (domestic)	gal.	.77	— .79
Linseed oil, raw, tank cars (domestic)	gal.	.73	— .74
Linseed oil, boiled, car lots (domestic)	gal.	.78	— .80

Olive oil, commercial	gal.	2.60 —	2.70
Palm, Lagos	lb.	.07½ —	.08
Palm, Niger	lb.	.07½ —	.08½
Peanut oil, crude, tank cars (f.o.b. mill)	lb.	.07 —	.07½
Peanut oil, refined, in bbls	lb.	.13 —	.13½
Rapeseed oil, refined in bbls	gal.	1.10 —	1.15
Rapeseed oil, blown, in bbls	gal.	1.20 —	1.25
Soya bean oil (Manchurian), in bbls. N. Y.	lb.	.08½ —	.09
Soya bean oil, tank cars, f.o.b., Pacific coast	lb.	.06 —	.07
FISH			
Light pressed Menhaden	gal.	$0.53 —	$0.55
Yellow bleached Menhaden	gal.	.55 —	.58
White bleached Menhaden	gal.	.57 —	.60
Blown Menhaden	gal.	1.00 —	....

Miscellaneous Materials

All f. o. b. New York Unless Otherwise Stated

Barytes, ground, white, f.o.b. Kings Creek, S. C.	net ton	$24.00 —	$30.00
Barytes, ground, off color, f.o.b. Kings Creek	net ton	22.00 —	26.00
Barytes, crude, 88%@94% ba., Kings Creek	net ton	10.00 —	12.00
Barytes, floated, f.o.b. St. Louis	net ton	26.50 —	28.00
Barytes, crude, first grade, Missouri	net ton	10.00 —	....
Blanc fixe, dry	lb.	.05 —	.05½
Blanc fixe, pulp	net ton	60.00 —	65.00
Casein	lb.	.14 —	.18
Chalk, domestic, extra light	lb.	.05 —	.06
Chalk, domestic, light	lb.	.04½ —	.05½
Chalk, domestic, heavy	lb.	.04 —	.05
Chalk, English, extra light	lb.	.05 —	.07
Chalk, English, light	lb.	.05 —	.06
Chalk, English, dense	lb.	.04½ —	.05
China clay, (Kaolin) crude, f.o.b. mines, Georgia	net ton	8.00 —	10.00
China clay (Kaolin) washed, f.o.b. Georgia	net ton	12.00 —	15.00
China clay (Kaolin) powdered, f.o.b. Georgia	net ton	18.00 —	22.00
China clay (Kaolin) crude f.o.b. Virginia points	net ton	8.00 —	12.00
China clay (Kaolin) ground, f.o.b. Virginia points	net ton	15.00 —	40.00
China clay (Kaolin), imported, lump	net ton	25.00 —	35.00
China clay (Kaolin), imported, powdered	net ton	30.00 —	35.00
Feldspar, crude, f.o.b. Maryland and North Carolina points	gross ton	8.00 —	14.00
Feldspar, crude, f.o.b. Maine	net ton	7.50 —	10.00
Feldspar, ground, f.o.b. Maine	net ton	21.00 —	23.00
Feldspar, ground, f.o.b. North Carolina	net ton	17.00 —	21.00
Feldspar, ground, f.o.b. N. Y. State	net ton	17.00 —	21.00
Feldspar, ground f.o.b. Baltimore	net ton	27.00 —	30.00
Fuller's Earth, f.o.b. New York	net ton	16.00 —	17.00
Fuller's earth, granular, f.o.b. Fla.	net ton	25.00 —	....
Fuller's earth, powdered, f.o.b. Fla.	net ton	18.00 —	....
Fuller's earth, imported, powdered	net ton	25.00 —	35.00
Graphite, crucible, 90% carbon, Ashland, Ala	lb.	.... —	.09
Graphite, crucible, 85% carbon, Ashland, Ala	lb.	.07 —	.09
Graphite, higher lubricating grades	lb.	.11 —	.40
Pumice stone, imported, lump	lb.	.04 —	.50
Pumice stone, domestic, lump	lb.	.06 —	....
Pumice stone, ground	lb.	.04 —	.07
Quartz (acid tower) fist to head, f.o.b. Baltimore	net ton	.... —	10.00
Quartz (acid tower) 1½@2 in., f.o.b. Baltimore	net ton	.... —	14.00
Quartz (acid tower) rice, f.o.b. Baltimore	net ton	.... —	17.00
Quartz, lump, f.o.b. North Carolina	net ton	5.00 —	7.50
Shellac, orange fine	lb.	1.00 —	1.05
Shellac, orange superfine	lb.	1.05 —	1.10
Shellac, A. C. garnet	lb.	.90 —	.95
Shellac, T. N.	lb.	.85 —	.95
Soapstone	ton	15.00 —	25.00
Sodium Chloride	long ton	.... —	17.50
Talc, paper-making grades, f.o.b. Vermont	ton	12.00 —	22.00
Talc, roofing grades, f.o.b. Vermont	ton	9.50 —	15.00
Talc, rubber grades, f.o.b. Ve mont	ton	12.00 —	18.00
Talc, powdered, Southern, f.o.b. cars	ton	12.00 —	15.00
Talc, imported	ton	50.00 —	60.00
Talc, California Talcum Powder grade	ton	20.00 —	30.00

Refractories

Bauxite brick, 56% Al., f.o.b. Pittsburgh	1,000	160
Chrome brick, f.o.b. Eastern shipping points	net ton	100-110
Chrome cement, 40-45% Cr_2O_3	net ton	55-60
Chrome cement, 40-45% Cr_2O_3, sacks, in car lots, f.o.b. Eastern shipping points	net ton	60-65
Fire clay brick, 1st quality, 9-in. shapes, f.o.b. Pennsylvania, Ohio and Kentucky works	1,000	55-60
Fire clay brick, 2nd quality, 9-in. shapes, f.o.b. Pennsylvania, Ohio and Kentucky works	1,000	45-50
Magnesite brick, 9-in. straight	net ton	110
Magnesite brick, 9-in. arches, wedges and keys	net ton	121
Magnesite brick, soaps and splits	net ton	134
Silica brick, 9-in. sizes, f.o.b. Chicago district	1,000	65-70
Silica brick, 9-in. sizes, f.o.b. Birmingham district	1,000	56-61
Silica brick, 9-in. sizes, f.o.b. Mt. Union, Pa.	1,000	55-60

Ferro-Alloys

All f.o.b. Works

Ferro-carbon-titanium, 15-18%, f.o.b. Niagara Falls, N. Y.	net ton	$200.00 —	$225.00
Ferro-chrome, per lb. of Cr. contained, 6-8% carbon, carlots	lb.	.16 —	.17
Ferro-chrome, per lb. of Cr. contained, 4-6% carbon, carlots	lb.	.17 —	.18
Ferro-manganese, 76-80% Mn, domestic	gross ton	120.00 —	125.00
Ferro-manganese, 76-80% Mn, English	gross ton	110.00 —	115.00
Spiegeleisen, 18-22% Mn	gross ton	60.00 —	65.00
Ferro-molybdenum, 50-60% Mo, per lb. of Mo	lb.	2.00 —	2.50
Ferro-silicon, 10-15%	gross ton	55.00 —	60.00
Ferro-silicon, 50%	gross ton	78.00 —	80.00
Ferro-silicon, 75%	gross ton	140.00 —	145.00
Ferro-tungsten, 70-80%, per lb. of contained W	lb.	.55 —	.60
Ferro-uranium, 35-50% of U, per lb. of U content	lb.	7.00 —	....
Ferro-vanadium, 30-40% per lb. of contained V	lb.	6.00 —	6.50

Ores and Semi-finished Products

All f.o.b. New York, Unless Otherwise Stated

Bauxite, 52% Al. content, less than 2% Fe_2O_3, up to 20% silica, not more than 14% moisture	gross ton	$10.00 —	$11.00
Chrome ore, Calif. concentrates, 50% min. Cr_2O_3	unit	.60	65
Chrome ore, 50%, Cr_2O_3, f.o.b. Atlantic Seaboard	unit	.55 —	.60
Coke, foundry, f.o.b. ovens	net ton	6.25 —	7.00
Coke, furnace, f.o.b. ovens	net ton	5.00 —	5.50
Coke, petroleum, refinery, Atlantic Seaboard	net ton	21.00 —	22.00
Fluor spar, lump, f.o.b. Tonuco, New Mexico	net ton	17.50 —	....
Fluor spar, standard, domestic washed gravel Kentucky and Illinois mines	net ton	22.50 —	25.00
Ilmenite, 52% TiO_2, per lb. ore	lb.	.01½ —	.01½
Manganese Ore, 50% Mn, c.i.f. Atlantic seaport	unit	.40 —	.45
Manganese ore, chemical (MnO_2)	gross ton	60.00 —	65.00
Molybdenite, 85% MoS_2, per lb. of MoS_2, N. Y.	lb.	.55 —	.60
Monazite, per unit of ThO_2, c.i.f., Atlantic seaport	unit	35.00 —	....
Pyrites, Spanish, fines, c.i.f., Atlantic seaport	unit	.12 —	....
Pyrites, Spanish, furnace size, c.i.f., Atlantic seaport	unit	.17 —	....
Pyrites, domestic, fines, f.o.b. mines, Ga.	unit	.12 —	.14
Rutile, 95% TiO_2 per lb. ore	lb.	.15 —	....
Tungsten, Scheelite, 60% WO_3 and over, per unit of WO_3 (nominal)	unit	3.75 —	4.00
Tungsten, Wolframite, 60% WO_3 and over, per unit of WO_3, N. Y. C.	unit	4.00 —	4.25
Uranium Ore (Carnotite) per lb. of U_3O_8	lb.	2.75 —	3.00
Uranium oxide, 96% per lb. contained U_3O_8	lb.	2.75 —	3.00
Vanadium pentoxide, 99%	lb.	12.00 —	14.00
Vanadium Ore, per lb. of V_2O_5 contained	lb.	1.50 —	....
Zircon, washed, iron free	lb.	.05 —	....

Non-Ferrous Metals

New York Markets

	Cents per Lb
Copper, electrolytic	15.00
Aluminum, 98 to 99 per cent	27.50
Antimony, wholesale lots, Chinese and Japanese	5.25@5.37½
Nickel, ordinary (ingot)	43.00
Nickel, electrolytic	45.00
Tin, 5-ton lots	34.02½
Lead, New York, spot	5.37½
Lead, E. St. Louis, spot	6.25
Zinc, spot, New York	7.00
Zinc, spot, E. St. Louis	6.75

OTHER METALS

Silver (commercial)	oz.	66¾
Cadmium	lb.	1.40@1.50
Bismuth (500 lb. lots)	lb.	2.40
Cobalt	lb.	5.00
Magnesium (f.o.b. Philadelphia)	lb.	1.35
Platinum	oz.	75.00
Iridium	oz.	350.00@400.00
Palladium	oz.	75.00
Mercury	75 lb.	45.00

FINISHED METAL PRODUCTS

	Warehouse Price Cents per Lb.
Copper sheets, hot rolled	21.50
Copper bottoms	32.00
Copper rods	28.00
High brass wire and sheets	20.25
High brass rods	18.25
Low brass wire and sheets	29.50
Low brass rods	18.50
Brazed brass tubing	35.25
Brazed bronze tubing	40.50
Seamless copper tubing	25.00
Seamless high brass tubing	24.00

OLD METALS—The following are the dealers' purchasing prices in cents per pound:

	New York			
	Current	One Year Ago	Cleveland	Chicago
Copper, heavy and crucible	12.00	17.00	10.00	10.50
Copper, heavy and wire	11.50	16.00	9.50	10.00
Copper, light and bottoms	10.00	14.00	9.00	9.00
Lead, heavy	4.00	4.75	4.00	4.00
Lead, tea	3.00	3.75	3.00	3.50
Brass, heavy	7.00	10.50	7.00	10.00
Brass, light	5.50	7.50	5.00	5.50
No. 1 yellow brass turnings	6.50	10.00	5.50	5.50
Zinc	4.50	5.00	3.00	4.25

Structural Material

The following base prices per 100 lb. are for structural shapes 3 in. by ¼ in. and larger, and plates ¼ in. and heavier, from jobbers' warehouses in the cities named:

	New York			Cleveland		Chicago	
	Current	One Month Ago	One Year Ago	Current	One Year Ago	Current	One Year Ago
Structural shapes	$3.80	$4.15	$3.47	$3.58	$3.37	$3.58	$3.47
Soft steel bars	3.70	4.15	3.37	3.34	3.27	3.48	3.37
Soft steel bar shapes	3.70	4.15	3.37	3.48	3.27	3.48	3.37
Soft steel bands	4.65	5.50	4.07	6.25	....	....	....
Plates, ¼ to 1 in. thick	4.00	4.15	3.67	3.78	3.57	3.78	3.67

Industrial

Financial, Construction and Manufacturers' News

Construction and Operation

Connecticut

DANBURY — The Beaver Brook Paper Mills, Inc., Beaver Brook St., plans to build a 1-story, 75x150-ft. addition to its manufacturing plant. Private plans.

Indiana

MARION—The Standard Glass Co. plans to build a 1-story glass factory. Estimated cost, $75,000. Private plans.

TERRE HAUTE—The Union Hospital will receive bids after Feb. 1 for the construction of a 6-story, 80x120-ft. hospital on North Eighth St. Estimated cost, $337,000. Johnson, Miller & Miller, archts.

Iowa

COLLINS — The Bd. Educ. will soon award the contract for the construction of a 2-story, 69x109-ft. high school. A chemical laboratory will be installed in same. Estimated cost, $150,000. B. L. Mead, secy. T. Thorson, Forest City, archt.

Massachusetts

LEOMINISTER—The Viscoloid Co. will build a 1-story, 20x95-ft. addition to its plant for the manufacture of viscoloid sheetings. Estimated cost, $15,000.

Michigan

GLADSTONE—The Bd. Educ. will receive bids until March 1 for the construction of a 2-story, 120x130-ft. junior high school on Main St. A chemical laboratory will be installed in same. Estimated cost, $140,000. G. Arutzen, Escanaba, archt. and engr.

Montana

MILES CITY—The Custer Co. Free High School will soon award the contract for the construction of a 3-story high school. A chemical laboratory will be installed in same. Estimated cost, $400,000. G. F. Ingersoll, clk. W. A. Dedrick, Billings, archt. Noted Jan. 5.

New York

BROOKLYN—R. Embers, 209 King St., has awarded the contract for the construction of a 1-story, 60x100-ft. foundry on Richards St., to T. Drysdale, 250 Baltic St. Estimated cost, $35,000.

North Dakota

MANDAN—The city is having plans prepared for the construction of a filtration plant and new reservoir or repairs to the present one. Estimated cost, $150,000.

Ohio

COLUMBUS—The Ohio State University plans to build 13 buildings to include a chemistry building. Estimated cost, $4,000,000.

SALEM—B. M. French, city engr., plans to construct a new building to include a filtering and settling basin with complete pumping and purification plant. Estimated cost, $800,000.

SANDUSKY—The Hard Color Products Co., South Columbus Ave., has awarded the contract for the construction of a 1-story factory for repair work, to H. K. Ferguson Co., 6223 Euclid Ave., Cleveland. Estimated cost, $50,000.

Oklahoma

LINCOLNVILLE—The Natl. Tripoli Co., Chamber of Commerce Bldg., Joplin, Mo., will receive bids until Jan. 25 for the construction of a 2-story factory to have a capacity of 100 tons. Estimated cost, $130,000. G. A. Smith, pres.

Pennsylvania

PHILADELPHIA—The Amer. Eng. Co., Speviva St. and Wheatsheaf Lane, has awarded the contract for the construction of a 1-story, 50x100-ft. foundry and machine shop to the Austin Co., Bulletin Bldg. Estimated cost, $25,000. Noted Dec. 29.

PHILADELPHIA—H. T. Potts & Co., Inc., 316 North Third St., has awarded the contract for the construction of a 1-story foundry on D and Erie Sts., to W. Steel & Sons Co., Sixteenth and Arch Sts. Estimated cost, over $15,000.

South Dakota

EGAN—The Bd. Educ. is having plans prepared for the construction of a 1- or 2-story consolidated school. A chemical laboratory will be installed in same. Estimated cost, $150,000. Schumacher & Finkelhor, 316 Paulton Blk., Sioux Falls, archts.

Texas

AUSTIN—The city plans an election to vote on $20,000 bonds to construct improvements to the sewage disposal plant. Address W. D. Yett, Mayor, or C. E. Leonard, engr.

Wisconsin

ANTIGO — The Bd. Educ., c/o R. A. Brandt, is having plans prepared for the construction of a 2-story, 127x225-ft. junior high school on Main St. A chemical laboratory will be installed in same. Estimated cost, $250,000. Oppenhammer & Obel, Wausau, archts.

GOODMAN — The School Bd. plans to build a 2-story, 90x125-ft. high and grade school. A chemical laboratory will be installed in same. Estimated cost, $125,000. E. Tough, 24 East Mifflin St., Madison, archt.

Quebec

MONTREAL EAST—The Royal Duke Oil Co., 157 St. James St., Montreal, will receive bids until Jan. 15 for the construction of a plant for the purification of gasoline distilled, etc. Estimated cost, $50,000. W. B. Richards & Co., 203 Bernard Ave., W., engr.

Industrial Notes

THE FISHER GOVERNOR CO., Marshalltown, Iowa, has taken over the manufacturing of the O-B regulating valve, formerly made by the Ohio Brass Co. In the future the valve will be known as the Fisher pressure regulating valve.

F. J. RYAN & Co., Franklin Trust Bldg., Philadelphia, are completing the installation of a large electric processing oven at the Thermoid Rubber Co., Trenton, N. J. This equipment is the second large processing equipment built by this company. The chief interest surrounds the possibility of solvent recovery owing to the form of heat used.

THE ELECTRIC FURNACE Co., Alliance, O., is installing a complete automatic heat-treating set at the new plant of the C. H. Wills Co., of Marysville, Mich. The set is designed to treat all kinds of automobile parts and consists of a 200-kw. hardening furnace, a motor operated quench and a 200-kw. drawing furnace. A 200-kw. Baily annealing furnace is being installed at the Springfield plant of the Ohio Steel Foundries Co., and a similar outfit but with 300 kw. electrical capacity has been ordered for export to the Oddehome Steel Corp. of Norway.

THE WISE ELECTRO-SHERARDIZING CORP. has started production at 2326 South Western Ave., Chicago, Ill. This company gives a sherardizing treatment to metal by an electric process as distinguished from the gas process of heating.

THE MEMPHIS IRON & STEEL Co. started operations at the first unit of the new mill recently, and is producing bars and round iron.

THE AUSTIN MACHINERY CORP. of Chicago has established a distributing branch in Memphis, Tenn., for the Arkansas and Tennessee territories. J. M. McCampbell will have charge of the new organization.

THE ELECTRIC FURNACE CONSTRUCTION Co., Philadelphia, announces the starting of a "Greaves-Etchells" electric furnace at the Holmes Foundry Co.'s plant, Port Huron, Mich., for refining and superheating molten cupola metal. It has been found possible by short-treatment in the electric furnace to increase the fluidity of the metal and to largely eliminate sulphur. The cupola iron contained 0.102 per cent average sulphur, and the finished product showed only 0.023 per cent sulphur. Time taken was about forty minutes. Charges of cold scrap have also been run, consisting of 80 per cent cylinder scrap and 20 per cent iron borings. Sulphur in final product from the cold-melted heat was reduced to 0.013 per cent.

Manufacturers' Catalogs

HOLZ & Co., New York, has issued two new bulletins. No. 11 is on "The Eden-Foster Repeater Impact Testing Machine" for investigating the resistance of steel and other metals to fatigue procured by repeated stresses of small force, and No. 41 is on the "Burrows Defectoscope and Magnetic Analyzer" for the inspection of steel rails, rods, wire, cable and all other steel and iron stock of uniform section. Both booklets are illustrated.

INTERNATIONAL OXYGEN Co., Newark, N. J., calls attention to Bull. No. 61, covering the design, construction and operating characteristics of the I.O.C. system electrolytic oxygen-hydrogen generator type 1,000, which has just been published. The company announces that it will forward copies free of charge to anyone interested in the production of oxygen and hydrogen for industrial purposes.

Coming Meetings and Events

AMERICAN CERAMIC SOCIETY will hold its annual meeting Feb. 21 to 24, at Columbus, Ohio, with headquarters at the Deschler Hotel.

AMERICAN CHEMICAL SOCIETY will hold its sixty-first meeting at Rochester, N. Y., April 26 to 29.

AMERICAN ELECTROCHEMICAL SOCIETY will hold its spring meeting at Atlantic City April 21 to 23 inclusive. Headquarters will be at the Hotel Chalfonte.

AMERICAN INSTITUTE OF MINING AND METALLURGICAL ENGINEERS will hold its spring meeting Feb. 14 to 17 in New York City.

AMERICAN SOCIETY FOR TESTING MATERIALS will hold its 1921 annual meeting in the New Monterey Hotel, Asbury Park, N. J., during the week of June 20.

COMMON BRICK MANUFACTURERS' ASSOCIATION OF AMERICA will hold its annual meeting at the Hotel Pennsylvania, New York City, Jan. 31 to Feb. 4.

COMPRESSED GAS MANUFACTURERS' ASSOCIATION will hold its eighth annual meeting, Monday, Jan. 17, at 2 p.m., at the Hotel Astor, New York, and its eighth annual dinner at the same place that evening.

NATIONAL PETROLEUM CONGRESS will meet at the Hotel Baltimore, Kansas City, Mo., March 22 to 25.

NEW JERSEY CHEMICAL SOCIETY holds a meeting at Stetters Restaurant, 842 Broad St., Newark, N. J., the second Monday of every month.

SOCIETY OF CHEMICAL INDUSTRY holds its Perkin Medal Award Meeting at Rumford Hall, Chemists' Club, New York, on Jan. 14.

THE SEVENTH EXPOSITION OF CHEMICAL INDUSTRIES will be held during the week of Sept. 12, in the Eighth Coast Artillery Armory, New York City.

The following chemical societies will meet at Rumford Hall, Chemists' Club, New York City, as follows: Jan. 14, Society of Chemical Industry, Perkin Medal award; Feb. 11, American Electrochemical Society, joint meeting with Society of Chemical Industry, American Chemical Society and Société de Chimie Industrielle; March 11, American Chemical Society, Nichols Medal award; March 25, Society of Chemical Industry; April 22, Society of Chemical Industry, joint meeting with American Electrochemical Society, Société de Chimie Industrielle and American Chemical Society; May 6, American Chemical Society; May 13, Société de Chimie Industrielle, joint meeting with American Chemical Society, Society of Chemical Industry and American Electrochemical Society; May 20, Society of Chemical Industry; June 10, American Chemical Society.